THE USE OF AUGMENTED REALITY-ENHANCED READING BOOKS FOR VOCABULARY ACQUISITION WITH STUDENTS WHO ARE DIAGNOSED WITH SPECIAL NEEDS

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by

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ABSTRACT

During this collective case study, I explored the use of augmented reality books on an iPad 2 with students diagnosed with disabilities. Students in this study attended a high school life skills class in a rural school district during the fall 2013 semester. Four students participated in this study, two males and two females. Specifically, the purposes of this study were to (a) describe students’ processing of the augmented reality enhanced books by analyzing their spontaneous and prompted verbalizations; (b) identify students’ perceived vocabulary word knowledge through a survey that is completed before and after the augmented reality reading activity; (c) examine students’ vocabulary word knowledge as mean scores of criterion-referenced worksheets that were completed before and after the augmented reality activity and by their responses to prompted questions within the AR book. This study was guided by the following central research question: How does the use of an augmented reality book that is enhanced with layers of technological, instructional, and conceptual scaffolds, influence vocabulary knowledge and verbal responses of students who are diagnosed with special needs?

The iPad2, reading textbook, Aurasma, Muvizu, Audacity, and Glogster.edu were used to create the AR books. This study lasted for four consecutive weeks, and collected approximately 24 hours of data, which consisted of student observations, transcripts, video data, perceived knowledge surveys, and criterion referenced worksheets. Data were analyzed using an adapted coding scheme from Zimmerman and colleagues (2013), a perceived knowledge survey, and by assessing vocabulary depth knowledge through a matching worksheet, and using an adapted coding scheme by Christ, Wang, and Chiu (2011).

Findings indicated that students participated in the perceptual talk category most often followed by conceptual, device use, unable to answer, affective, questioning, connecting, and learner awareness. Another finding was that students’ perceptions of vocabulary knowledge did not always match what was reflected in the transcripts, however, students’ perceptions did move in a positive direction. A third finding was students either maintained their knowledge of vocabulary words, or increased their scores from before the activity to after the activity on the worksheet. In addition, students created novel sentences using the target vocabulary words more than half of the time. Some implications for future research include varying the prompts to elicit a broader and deeper range of processing types. In addition, given this sample, it is unclear as to the effectiveness of asking students their perceptions of what vocabulary they do and do not know prior to reading. Lastly, providing students with a more direct prompt asking for a novel sentence might elicit a unique expressive response that could be categorized as a higher-level sentence.
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Chapter 1
Introduction

Due to the No Child Left Behind Act (NCLB) signed into effect by former President George W. Bush in 2002, all students must be able to demonstrate progress in reading beginning in third grade and continuing throughout their high school careers (Browder, Gibbs, Ahlgrimm-Delzell, Courtade, Mraz, & Flowers, 2009; U.S. Department of Education, 2004). One of the main tenets of NCLB is that all children must learn to read at or above grade level before the third grade by the 2013-2014 school year (U.S. Department of Education, 2004). In Pennsylvania, students’ reading and math competencies are assessed by the Pennsylvania System of School Assessment (PSSA). According to the Pennsylvania Department of Education (2013a), approximately 25.9% of third grade students who are classified as “typically developing” (not diagnosed with a disability) scored at the basic or below basic level of proficiency in reading. During the same school year (2011-2012), students in third grade who were labeled as belonging to the Individualized Education Plan (IEP) category completed this assessment with the necessary accommodations as described in their IEPs. Test scores revealed that over half, or 58.4% of third grade students who require an IEP scored at basic or below basic levels of proficiency in reading.

For some students, this statewide assessment may not be appropriate, nor is it applicable to their learning trajectory; therefore, these students may complete an adapted test, known as the Pennsylvania Alternative System of Assessment (PASA) (U.S. Department of Education, 2004; Pennsylvania Department of Education, 2013b). Less than 1% of students who have IEPs qualified for the PASA. Approximately 42% of the third grade students performed at the basic or
below basic levels in reading (Pennsylvania Department of Education, 2013b). These statistics are staggering; the data provided above adequately demonstrate that not all students are reading at the third grade level.

In 2000, the National Reading Panel report developed by the National Institute of Child Health and Human Development (NICHHD) identified vocabulary as one of the five main features of reading (National Institute of Child Health and Human Development, 2000a). Vocabulary learning is an ongoing, continuous, and dynamic process (Wood, 2001). Being able to properly understand words and their associated meanings contributes to the ability to acquire appropriate comprehension skills, which in turn leads to greater reading independence, and enables individuals to communicate effectively and efficiently (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006; Browder, Gibbs, Ahlgrim-Delzell, Courtade, Mraz, & Flowers, 2009; Gersten, Fuchs, Williams, & Baker, 2001; Lipson & Wixson, 1997; National Institute of Child Health and Human Development, 2000a; National Institute of Child Health and Human Development, 2001; Pullen & Cash, 2011). Some students may require specialized and explicit instruction in reading (Lloyd, 2011). Features of explicit instruction include (a) identifying criteria to be mastered prior to the learning activity, (b) actively participating, (c) activating prior knowledge, (d) completing a task analysis, and (e) providing specified corrective feedback (Snow, 2002). This explicit instruction is known as direct instruction, which can be defined as a teacher-led instructional method (Friend, 2011; Marzano, 2004). Some strategies which can be used to supplement direct instruction include: repetitive exposure to vocabulary words, contact with the same vocabulary words in various contexts, shared reading, and technology tools (Bölte, Golan, Goodwin, & Zwaigenbaum, 2010; Friend, 2011; National Institute of Child Health and Human Development, 2000a; Pullen & Cash, 2011; Soto & Dukhovny, 2008; Stearns, 2012; Wissick & Gardner, 2011).
The use of technologies such as mind mapping tools, audio books, E-books, eReaders, internet accessible devices, text-to-speech software, and assistive technologies can also help students with reading (Bölte, Golan, Goodwin, & Zwaigenbaum, 2010; Friend, 2011; National Institute of Child Health and Human Development, 2000a; Pullen & Cash, 2011; Stearns, 2012; Wissick & Gardner, 2011). One technology that has caught the interest of teachers and researchers is augmented reality (AR) books; however, literature surrounding AR books is limited and exploratory. Augmented reality books are similar to physical books, with the exception that pages found within an AR book include virtual content through the use of a device (Abas & Zaman, 2011; Billinghurst & Dünser, 2012; Grasset, Dünser, & Billinghurst, 2008, December; Grasset, Dünser, & Billinghurst, 2008, September; Matcha & Rambli, 2012). These AR books have three elements: physical book, a computer, and a device that can display the augmented content (Matcha & Rambli, 2012).

Augmented reality has unexplored potential in education, specifically for vocabulary learning, and its ability to seamlessly support students in a natural environment. This area of research is limited due to several factors: (a) most tools being used to view AR books are dated (Billinghurst et al., 2001a, Smith, Luckin, Fraser, Williams, Dünser, Hornecker, Woolard, & Lancaster, 2007; Vate-U-Lan, 2012), (b) most studies have involved students who are typically developing with the exception of Vate-U-Lan (2012), who conducted a small group trial with three levels of students one being special needs (Billinghurst et al., 2001a, Smith, et.al, 2007; Hornecker & Dünser, 2007), and (c) most studies focus on engagement, motivation, recall, and collaboration, not specifically vocabulary word attainment (Billinghurst et al., 2001a; Hornecker & Dünser, 2007; Smith, et.al, 2007; Vate-U-Lan, 2012).
Theoretical Framework: Scaffolding as Conceptual Support during Learning

This study aims to inform the use of augmented reality through the lens of scaffolding, which purports to support students at theoretically-optimal levels of complexity (Jalongo, 2010; Kim & Hannafin, 2011; Raes, Schellens, Wever & Vanderhoven, 2012; Wray, 2012). Scaffolding is based on Vygotsky’s socio-cultural theory known as the Zone of Proximal Development (ZPD) (Vygotsky, 1978). When supported in the ZPD, by a knowing other, students can receive assistance from peers, instructors, and tools to develop understanding or a skill (McNeill, Lizotte, Krajcik, & Marx, 2006; National Research Council, 2000). The term “scaffold” associated with other direct human interaction was first introduced by Wood, Bruner, and Ross (1976, p.90) who described a scaffold as a “process that enables a child or novice to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts.” In other words, a scaffold is a strategy that is used to support a student in accomplishing a task that s/he cannot complete on his/her own by providing prompts, clues, cues, tools, resources, and hints (Azevedo, Cromley, & Seibert, 2004; Barzilai, & Blau, 2014; Chen, Kao, & Sheu, 2003; Collins, 2006; Freeman, 2012; Graves, Juel, & Graves, 1998; McNeill, Lizotte, Krajcik, & Marx, 2006; Paris, Wixson, & Palincsar, 1986; Pea, 2004; Puntambekar & Hubscher, 2005; Quintana, Shin, Norris, & Soloway, 2006; Renninger & Granott, 2005; Sawyer, 2006; Yussof & Zaman, 2011). Scaffolds are added based on students’ needs, to help them with the aid of a teacher or tool, and/or to attain a skill that is just out of reach. The scaffolds are then modified according to a students’ progress. Afterwards the scaffolds should be faded and removed once a learner becomes independent with the skill (Sawyer, 2006).

Scaffolding can be provided by a teacher to guide and support a student. A key aspect of scaffolding is that this support is gradually faded as a student becomes more independent with the target skill (Chen, Kao, & Sheu, 2003; Collins, 2006; De León, 2012; Guzdial, 1994; Kim &
Scaffolding has also been conceptualized to include not only an adult or teacher, but also peers, tools, technology, cues, and prompts (Barzilai & Blau, 2014; Devolder, van Braak, & Tondeur, 2012; Guzdial, 1994; Hill & Hannafin, 2001; Lai & Law, 2006; National Joint Committee on Learning Disabilities, 2008; National Research Council, 2000; Reiser, 2004; Renninger & Granott, 2005; Rosenshine & Meister, 1992, Zydney, 2010). Students must internalize these supports, in order for them to be able to independently perform at “…a higher cognitive level” (Salomon, Globerson, & Guterman, 1989, p. 620).

Hannafin, Land, and Oliver (1999) and Hill and Hannafin (2001) identified four types of scaffolds: conceptual, metacognitive, procedural, and strategic. This current study embedded conceptual, technical, and instructional scaffolds to inform the design of the augmented reality books. A conceptual scaffold directs students to ideas and concepts to consider during a specific learning activity by providing prompts and cues (Azevedo, Cromley, & Seibert, 2004; Hannafin, Land & Oliver, 1999; Hill & Hannafin, 2001; Huang, Wu, & Chen, 2012). Instructional scaffolds help students achieve goals that are above their ability to work alone (Xun & Land, 2004). According to Reiser (2004), a software scaffold is “…a case in which the tool changes the task in some way so that learners can accomplish tasks that would be otherwise out of their reach” (p. 275). Expanding this idea of software scaffolding to technical scaffolding gives an opportunity for supports to be provided online or embedded within a software program (Devolder, van Braak, & Tondeur, 2012; Lai, & Law, 2006; Reiser, 2004; Yelland & Masters, 2007).
Problem Statement

Presently, mobile augmented reality studies are in their infancy. Therefore, very little is understood about how students with special needs can use mobile devices with augmented reality to build their vocabulary skills. Research on how augmented reality books can be used effectively and designed efficiently using empirically supported strategies, such as scaffolds, are limited, specifically in regards to vocabulary learning. Some research shows that augmented reality and mobile devices, when used together, can motivate students, engage learners in problem solving, and promote collaboration (Billinghurst et al., 2001a; Hornecker & Dünser, 2007; Mahadzir & Phung, 2013; Smith, et.al, 2007; Vate-U-Lan, 2012). The research on scaffolding has demonstrated that it can aid students in attaining goals through necessary supports (National Research Council, 2000). This study informs the existing base of research on both scaffolding and AR books by examining vocabulary attainment of students with disabilities. Given prior research findings on the effectiveness of technology-based scaffolds in classroom settings (Quintana et al., 2006), this study extends the use of scaffolds to mobile devices, specifically augmented reality books for students with disabilities. This study assumed scaffolding strategies embedded into AR books to support learners in their vocabulary development provided them with supplemental conceptual support at the same time and same place they were reading.

This study is significant because as of 2013, NCLB states that all students must be able to read at or above grade level. This is not necessarily the case as identified by the statistics provided; therefore, some students may require a structured, teacher-focused instructional method to aide them in obtaining appropriate reading skills. Technology can be used to supplement direct instruction methods, and one new technology that will be explored is AR books. These books have been used with typically developing students using dated technologies and more as a tool to
promote engagement and motivation around reading. This study investigated how AR books using image-based recognition and a mobile device can help students diagnosed with disabilities with their vocabulary skills. This was completed through a collective case study and explored participants’ prompted and spontaneous verbalizations during the activity. This is an important research topic to explore, as it brings awareness not only to the field of special education, but works at developing the field of educational technology in research and designing a study with this population of students. This work is a multi-disciplinary contribution to the fields of vocabulary learning, special education, and augmented reality.

**Research Purpose**

The purpose of this qualitative study was to explore the use of augmented reality books on an iPad 2 with students diagnosed with disabilities. Specifically, the purposes of this study were to: (a) provide rich descriptions of students’ processing of the augmented reality enhanced books by analyzing their spontaneous and prompted verbalizations; (b) identify students’ perceived vocabulary word knowledge through a survey that is completed before and after the augmented reality reading activity; and (c) demonstrate students’ vocabulary word knowledge as mean scores of criterion-referenced worksheets that are completed before and after the augmented reality activity and by their responses to prompted questions within the AR book. This study described the influence that scaffolded augmented reality books have on students’ verbalizations (both prompted and spontaneous) and vocabulary knowledge with students who attended a high school life skills class in a small, public, and rural school district.
**Research Questions**

The study was guided by the following central research question: how does the use of an augmented reality book that is enhanced with layers of technological, instructional, and conceptual scaffolds influence vocabulary knowledge and verbal responses of students who are diagnosed with special needs? This main question was guided by the following related sub questions:

1. How do students’ spontaneous and prompted verbalizations while using the augmented reality enhanced textbook reflect processing of vocabulary words using a coding scheme adapted from Zimmerman, Land, McClain, Mohney, Choi, and Salman (2013)?

2. What are the perceived effects of the augmented reality-enhanced book on students’ vocabulary knowledge as measured by a perceived knowledge survey taken before and after the augmented reality activity?

3. What are the effects of the augmented reality-enhanced book on students’ recognition of vocabulary words, as measured by a matching activity of the correct definition on a worksheet before and after the activity and on their sample sentences provided by embedded questions within the AR book? Vocabulary knowledge will be analyzed using categories defined by Christ, Wang, and Chiu (2011).
Chapter 2
Literature Review

Learning to read is a multifaceted process, which is a common difficulty for students diagnosed with disabilities (Wright, Fugett, & Caputa, 2013; Yaw, Skinner, Parkhurst, Taylor, Booher, & Chambers, 2011). Students who struggle in reading may do so for a variety of reasons, which include but are not limited to: biological issues, limited early reading experiences, low socio-economic status (SES), and/or language deficits (Catts & Kamhi, 2005; Iacono, 2004). Reading can be a problem area for students diagnosed with specific learning disabilities, who make up about 38% of the population of students who are eligible to receive special education services ages 3-21 (Aud, Hussar, Kena, Bianco, Frohlich, Kemp, & Tahan, 2011; Friend, 2011; Gersten, Fuchs, Williams, Baker, 2001). Reading can also be a challenge for students with intellectual disabilities and autism spectrum disorders, who make up about 7% and 5%, respectively, of the total population of students who require special education services (Aud, Hussar, Kena, Bianco, Frohlich, Kemp, & Tahan, 2011; Friend, 2011).

According to the “Matthew effect” students who are “proficient” readers are able to gain vocabulary knowledge because they read more often. Those who are “poor” readers often struggle, and therefore read less (Catts & Kahmi, 2005; McKeown, 2005; Stenovich, 1986). Consequently, students labeled as “poor” readers are often unable to catch up to their peers (Catts & Kahmi, 2005; McKeown, 2005). This could be due to a variety of reasons, which could include: (a) an inability to understand cues or hints of a word’s meaning from context, (b) limited understanding of strategies to use while reading, (c) lack of ability to draw inferences, (d) insufficient knowledge of learning strategies or meta-cognition skills, (e) lack of background
knowledge around a topic, (f) limited print exposure, and (g) quality and time spent on reading outside of school (Bryant, Goodwin, Bryant, & Higgins, 2003; Malatesha Joshi, 2005; McKeown, 2005; Rupley & Nichols, 2005). Due to these factors, these students are at a distinct disadvantage when compared to their typically developing peers. Students who are in segregated special education classes often differ in the quality of reading materials and time spent on reading instruction when compared to their peers (Catts & Kamhi, 2005). For instance, direct vocabulary word instruction provides students with supports they require to be successful in learning new words (Rupley & Nichols, 2005). In addition, vocabulary instruction that provides students with elaborated knowledge about a vocabulary word could also help (Bryant, Goodwin, Bryant, & Higgins, 2003).

Light and Smith (1993) claim that without access to appropriate literacy skill development, individuals may become restricted in their educational, vocational, and daily living activities, namely those who are struggling readers. This statement was directed towards those who are diagnosed with a speech or language disorder and require augmentative and alternative communication (AAC). However, it could be applied to many who require special education services. Not only do students who struggle with reading become affected at an individual level, they also are affected at a more societal level. For example, compared to their typically developing peers, students who are diagnosed with learning disabilities are more likely to drop out of high school and are less likely to attend a four-year college (National Joint Committee on Learning Disabilities, 2008).

Vocabulary Learning

Learning vocabulary words is a constant experience, which occurs throughout life (Blachowicz, Baumann, Manyak, & Graves, 2013; Rupley & Nichols, 2005; Simpson, 1987;
Wood, 2001). Reading vocabulary can be specifically defined as words that are found in print that can be decoded and understood by a student (White, Graves, Slater, 1990). Beck, McKeown, and Omanson (1987) identified three tiers of vocabulary words. Tier one words are simple words that occur in conversational turns and in early childhood books. Typically, these words are not explicitly taught. The second tier of vocabulary words include words that are used across the curriculum (Beck & McKeown, 2007; Beck, McKeown, & Kucan, 2013; Beck, McKeown, & Omanson, 1987; Pearson, Hiebert, & Kamil, 2007). Tier two words are favorable to teach because they can be found in printed texts, but not often in oral dialogue. These words require a deep understanding in order to use them properly (Beck, McKeown, & Kucan, 2013; Beck, McKeown, & Omanson, 1987; Fisher, Bates, Gurvitz, & Blachowicz, 2013; Pearson, Hiebert, & Kamil, 2007). Tier three words are low frequency words that are subject-specific such as in science or social studies topics (Beck, McKeown, & Kucan, 2013; Beck, McKeown, & Omanson, 1987; Fisher, Bates, Gurvitz, & Blachowicz, 2013).

**Vocabulary instruction**

There are two main schools of thought when it comes to vocabulary learning: indirect learning or explicit instruction (Lipson & Wixon, 1997; Steele & Mills, 2011). Vocabulary words should be taught using direct methods when the words are complex and may not be a part of a student’s everyday life (Lipson & Wixon, 1997). In addition, vocabulary words should be taught in a direct manner when it is essential to understand the word to comprehend a passage (Lipson & Wixon, 1997). These explicit instructional methods are the best method for students who are diagnosed with a learning disability (Steele & Mills, 2011).

Several strategies can be used to teach students vocabulary. For example, teaching students associated child-friendly definitions can be effective. Child-friendly definitions are
preferred to dictionary definitions (which are most often used) because dictionary definitions do not take into account the context of a vocabulary word, nor do they provide information regarding how to use the word properly and accurately in context (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006; Malatesha Joshi, 2005; McKeown, 2005; Vadas & Nelson, 2012). Brown, Collins, and Duguid (1989) purport that learning vocabulary words in isolated instances using a dictionary definition is not an effective strategy. Teaching students a child-friendly definition does not always work alone, but it may be effective when combined with contextual strategies, such as having the student use the word in a different context (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006; Fisher, Bates, Gurvitz, & Blachowicz, 2013; Lipson & Wixson, 1997; Steele & Mills, 2011). Bryant, Goodwin, Bryant, and Higgins (2003) describe several teaching implications from their review of literature around vocabulary instruction interventions for students with disabilities. They include (a) students must be engaged, (b) provide frequent exposure to vocabulary words across contexts, and (c) the number of vocabulary words required by learners should be small. In addition, Steele and Mills (2011) suggest using scaffolds to support students in their vocabulary knowledge development.

**Scaffolds**

Scaffolds align with Vygotsky’s concept of the Zone of Proximal Development (ZPD). According to Vygotsky (1978, p. 33) the ZPD can be defined as “the distance between the child’s developmental level as determined by independent problem solving and the higher level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.” The ZPD is the theoretical place between a child’s actual development (what a child can do independently), and their potential development (what a student cannot complete independently without assistance) (Crook, 1991; Mirzaei & Eslami,

Puntambekar and Hubscher (2005) described several scaffolding features that evolved from initial scaffolding attempts. For instance, the theory originally presumed that an adult or more advanced peer would be needed to share the same goal or meaning as the learner. This assumption of shared meaning via human-human interaction exclusively has evolved into an acceptance of scaffolds embedded within the environment through tools, technology, resources, and peers. In addition, in the area of ongoing support, two types of scaffolding were common: dynamic (ongoing) and adapted (scaled to the learner). Scaffolding types have now grown to include distributive (supports provided by peers not necessarily the adult), blanketed (same supports for all students), and passive supports (ongoing supports not provided). Lastly, in the area of fading, this characteristic originally involved a process of providing a student with less support over time as s/he becomes more independent. However, scaffolding supports are now oftentimes permanent in the classroom. The scaffolds in this study were not adapted for each individual student; they were adapted for the group. Therefore, fading the scaffolds may happen too fast and may make the skill of attaining vocabulary difficult (McNeill, Lizotte, Krajcik, & Marx, 2006).

**Types of Scaffolds**

A scaffold is a strategy that is used to support a student in accomplishing a task that s/he cannot complete on his/her own, often by providing prompts, clues, cues, and hints (Azevedo, Cromley, & Seibert, 2004; Barzilai, & Blau, 2014; Chen, Kao, & Sheu, 2003; Collins, 2006;
Scaffolds can further be delineated into delivery methods including: *embedded* or *non-embedded*, *explicit* or *tactic*, *static* or *adaptive*, *hard* or *soft*, and/or *interactive* or *dynamic* (Devolder, van Braak, & Tondeur, 2012). *Embedded* scaffolds are rooted in the activity in such a manner that the student must acknowledge them, while *non-embedded* scaffolds are dependent upon the students’ goals during the activity (Devolder, Van Braak, & Tondeur, 2012). The second type of scaffold is *explicit*, meaning a more direct tactic (Devolder, van Braak, & Tondeur, 2012). A *static* scaffold was identified by Hill and Hannafin (2001) as being stable, fixed, and unchanging. According to Guzidal (1994) the student can alter an adaptive scaffold, and support will differ depending on a student’s response to prompts and questions provided by the augmentation. Lastly, scaffolds that are *hard* often utilize technology supports. These have been found to support students in learning basic information. In contrast, *soft* scaffolds are typically adjustable and are provided by an expert teacher or peer (Devolder, van Braak, & Tondeur, 2012; Hannafin, Hill, Land, & Lee, 2014). *Interactive* or *dynamic* scaffolds allow for interactive assessment features and provide corrective feedback that is dependent upon a students’ response (Devolder, van Braak, & Tondeur, 2012).

### Conceptual Scaffolds

A conceptual scaffold is used to direct a learner regarding what to think about and consider during a learning activity. This can be done by providing students with prompts, think alouds, and/or cues (Azevedo, Cromley, & Seibert, 2004; Hannafin, Land & Oliver, 1999; Hill & Hannafin, 2001; Huang, Wu, & Chen, 2012). Research regarding scaffolds during reading have shown student gains in comprehension using reciprocal teaching strategies, which are scaffolds
provided by teachers and students as dialog during reading to promote comprehension (Palinscar & Brown, 1984; Paris, Wixson, & Palincsar, 1986). Scaffolds have also been used with vocabulary word acquisition through teacher facilitated read alouds (Christ, Wang, & Chiu, 2011) and to obtain higher scores regarding content of a passage (Chen, Teng, & Lee, 2011). In addition, the following research-based instructional and technical strategies were also built into the system.

**Instructional Scaffolds**

Instructional scaffolds can be used to help students achieve goals that are above their ability to work alone by having them focus on elements of an activity that they can master, and guiding them through more difficult tasks (Schunk, 2008; Xun & Land, 2004). The main strategy that was used during the augmentation is a processing model (Hill & Hannafin, 2001). A processing model provides students with a “mental model representation…that can assist learners with making connections between and across areas” (Hill & Hannafin, 2001, p.44). A specific processing model is the think aloud strategy. A think aloud strategy is used during reading to foster a rich understanding of text. A teacher typically does it; s/he describes what s/he is thinking about before, during, or after reading a passage (Davey, 1983). In addition, Freeman (2012) identified several instructional scaffolds pulled from the literature related to math learning for English language learners (ELLs). Although these strategies are specifically for math content, many can be adapted for the current study. These strategies include: (a) provide content that is understandable without oversimplifying, (b) use direct teaching for terminology which could include text-to-speech or read aloud functions, (c) teach prior knowledge, (d) give immediate purposeful feedback, and (e) break steps down into smaller, more manageable pieces.
Technical Scaffolds

This study also used the category of technical scaffolding for specific strategies. Instead of using a computer, this study used a mobile device and augmented reality to scaffold students’ vocabulary development. According to Quintana, Shin, Norris and Soloway (2006), along with McNeill, Lizotte, Krajcik, and Marx (2006), computer software can be used as a scaffolding tool by providing students with the necessary cognitive supports. Technical scaffolding can be provided online or embedded within software without the need for an instructor (Devolder, van Braak, & Tondeur, 2012; Lai & Law, 2006; Yelland & Masters, 2007). Technical tools can aid students in distributing his/her cognition (Reiser, 2004). Research has been done using mobile devices to scaffold individuals learning in science (Chen, Kao, & Sheu, 2003; Chen, Kao, Yu, & Sheu, 2004; Chen, Kao, Yu, & Sheu, 2004; Huang, Wu, & Chen, 2012; Yang, Gamble & Tang, 2012). Table 2.1 shows the scaffolds that were used to inform the design of the augmented reality enhanced book activity.

Table 2.1. Scaffolds used to inform the design of the augmentation.

<table>
<thead>
<tr>
<th>Strategies used during augmentation</th>
<th>Research Supporting Concept</th>
<th>Concept In Use</th>
</tr>
</thead>
</table>
| **Scaffold 1:** Provide simplified versions of the definitions found in the glossary of the textbook. | • Provide students with simple example sentences and explanations of vocabulary words in terms that students understand by using everyday language (Anderson-Inman, 2009; Christ, Wang, & Chiu, 2011; Fisher, Bates, Gurvitz, & Blachowicz, 2013; Graves, Juel, & Graves 1998; Hickman, Pollard-Durodola, & Vaughn, 2004; Marzano, 2004; Proctor, Dalton, & Grisham, 2007; Soto & Dukhovny, 2008; Steele & Mills, 2011). | • The avatar provided the student with a “child-friendly” definition of the vocabulary word.  
• The avatar also gave the student an example sentence, and asked the student to provide his/her own example sentence. |
<p>| <strong>Scaffold 2:</strong> Provide image supports that enhance the vocabulary word and its associated concepts | • Provide image supports that relate to the concepts being taught (Browder, Trela, Jimenez, 2007; Graves, Juel, &amp; Graves, 1998; Proctor, Dalton, &amp; Grisham, 2007; Ruple &amp; Nichols, 2005; Soto &amp; | • The avatar read aloud the vocabulary term while it was displayed textually |</p>
<table>
<thead>
<tr>
<th>Definition</th>
<th>Dukhovny, 2008; Steele &amp; Mills, 2011.</th>
<th>on the screen.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The avatar also read aloud a “child-friendly” definition that had image, video, and audio supports to enhance the concept.</td>
<td></td>
</tr>
</tbody>
</table>

**Scaffold 3: Use questioning prompts.**

- Ask questions that are open ended. Questions are presented before, during, and after the reading (Browder, Trela, & Jimenez, 2007; Soto & Dukhovny, 2008; Yelland & Masters, 2007).

- The avatar asked students questions before, during, and after the reading activity.
- Students were required to respond to questions about vocabulary words, definitions, and concepts in the book.

**Scaffold 4: Scaffold vocabulary rehearsal strategies.**

- Students repeat requested vocabulary word aloud. Students re-tell what the word means to them and use it appropriately in a sentence.

- The avatar read a vocabulary word aloud, “(communicate) means (to give information). What does (communicate) mean?” The avatar waited for the student to respond.

- Students should restate what the word means in his/her own words (Hickman, Pollard-Durodola, & Vaughn, 2004; Marzano, 2004).

- The avatar said the vocabulary word aloud, and then the avatar asked the child to repeat the word aloud.

- Student should say the word while viewing it. By doing so it reinforces a student’s phonological awareness and oral pronunciation skills (Beck & McKeown, 2007; Blachowicz, Baumann, Manyak, & Graves, 2013).

- Avatar provided the student with a sample sentence.

- The student then provided his/her own...
In addition to the scaffolds listed above, the following research based instructional and technical strategies, shown in table 2.2, were also incorporated into the design of the augmented reality reading textbook.

Table 2.2. Strategies used to inform the augmentation design.

<table>
<thead>
<tr>
<th>Strategies used during augmentation</th>
<th>Research supporting concept</th>
<th>Concept in use</th>
</tr>
</thead>
</table>
| **Strategy 1:** Provide visual and auditory content simultaneously. Content selected should be displayed appropriately through visual, audio, and/or textual stimuli. | ● The presentation of visual and auditory stimuli, may improve reading skills (Quintana et.al, 2004; Shamir & Shlafer, 2011; Stearns, 2012; Wang & Shen, 2012).  
 ● Listening to text being read aloud could help students with their vocabulary learning (Segers & Verhoeven, 2002). | ● The augmentation included both a visual representation of the vocabulary word and an auditory reading of the meaning of the vocabulary word. |
| **Strategy 2:** Audio narration of paragraphs is presented in a natural voice at a natural pace, which provides students with a model of appropriate intonation and inflection. | ● Providing a student with a digital support, such as text-to-speech, could simplify the reading process. It could also help with reading speed, writing skills, decrease stress related to reading, and may improve comprehension skills (Blachowicz, Baumann, Manyak, & Graves, 2013); | ● The avatar read the vocabulary word and associated text found on each page aloud. By doing so, the avatar paused, provided appropriate intonation, and included a natural speech pattern. Once the page was read aloud, the avatar asked students about concepts during the reading. The avatar also |
| Strategy 3: Utilize colored, realistic images and videos to represent content. Use three-dimensional animations to demonstrate abstract concepts. | • Use colored, real graphics to supplement visual representation of textual information (Anderson-Inman, 2009; Höfler & Leutner, 2007; Kim & Hannafin, 2011; Zainuddin, Zaman, & Ahmad, 2009).  
• Images and video representations could promote comprehension skills with students who are diagnosed with a disability (Izzo, Yurick, & McArrell, 2009; Wood, 2001). Embedding characters, text, audio, images, video, and other multimedia is an ideal feature of augmented reality (Dunleavy & Dede, 2014).  
• 3-D animations help students learn abstract concepts (Jono, Yasin, Za’ba, Ramakrisnan, & Isa, 2008; Wood, 2001).  
• Wood (2001) warned against frivolous animations that did not add to the content, but found that some animations |
| --- | --- |
|  | • The augmentation utilized both colored images and video clips to demonstrate concepts.  
• Characters, images, video, and audio were embedded within the augmentation.  
• The vocabulary words and associated definitions included image and text supports.  
• The vocabulary words demonstrated realistic, copyright free images from Microsoft word clipart and Google copyright free images when demonstrating the meanings of words and/or sample sentences.  
• 3-D modeling software was used to create video clips.  
• Characters, two dimensional (2-D) images, videos, 3-D animations, and audio were embedded within the |
| Strategy 4: Expose students to the vocabulary word multiple times during a session. | • Provide students with multiple exposures to a vocabulary word and its associated meaning multiple times in different settings (Blachowicz, Baumann, Manyak, & Graves, 2013; Blachowicz, Fisher, Ogle, Watts & Taffe, 2006; Christ, Wang, & Chiu, 2011; Fisher, Bates, Gurvitz, & Blachowicz, 2013; Freeman, 2012; Lipson & Wixson, 1997; National Institute of Child Health and Human Development, 2000b; Soto & Dukhovny, 2008; Stahl, 1986; Wood, 2001).
• Students need to be exposed to a vocabulary word and its meaning six to ten times (Borgia, 2009; Gersten, Fuchs, Williams, & Baker, 2001). | • The avatar read aloud the vocabulary word multiple times during the augmentation phase.
• The avatar enriched the vocabulary word by providing image, audio, and video supports depicting the word and its associated definition. |
| **Strategy 5: Introduce vocabulary prior to reading.** | • Introduce vocabulary words prior to reading the text, along with telling the student what the story will be about (Graves, Juel, & Graves, 1998; Hickman, Pollard-Durodola, & Vaughn, 2004; Soto & Dukhovny, 2008). | • The avatar read the vocabulary words aloud to the student prior to reading the textbook. |
| **Strategy 6:** Summarize the text and concepts at the end of the reading. | • Provide students with a summary of the main events in the text at the end of the story (Hickman, Pollard-Durodola, & Vaughn, 2004). | • After the entire story was read, the avatar provided the students with a brief summary of the main events in the story along with highlighting the vocabulary word in the text. |
Mobile Device to Scaffold Science Concepts

Chen, Kao, and Sheu (2003) used an operational definition of scaffolding to develop their mobile tool with a bird watching activity. In their definition, a teacher breaks down a large task into manageable pieces that can be completed by a student. Then the teacher plans for fading of the supports and provides ongoing, repetitive, and meaningful practice for the student. In addition, Chen, Kao, and Sheu (2005) and Chen, Kao, Yu and Sheu (2004), added that scaffolding can be used to help students foster their self-learning abilities by transferring information from the expert to the student via the mobile butterfly identification system. This case study built upon their idea that scaffolding is a technique that should be used when students have not yet reached mastery of a concept, and should be faded as students become more independent with their vocabulary skills. For example, students who have not yet reached mastery of the vocabulary terms in their reading textbook will use scaffolding strategies to reach those goals.

Yoon, Elinich, Wang, Steinmeier, and Tucker (2012) and Yoon, Steinmeier, Wang, and Tucker (2011) conducted studies with 119 sixth and seventh grade students during a field trip to the museum, studying the concept of electricity. Students were assigned to four groups: (1) no augmentations or knowledge building scaffolds were provided, (2) digital augmentation, (3) some scaffolds were present, and (4) both digital augmentation and scaffolds were provided. Researchers collected surveys that were based around students’ conceptual knowledge, worksheet responses, interviews, and field notes from observations. Researchers found that digital augmentation had an impact on the conceptual knowledge and higher order thinking skills in the area of electricity. Students in the fourth group were also able to generalize their understanding of electricity due to presence of scaffolds.
Augmented Reality

Augmented reality brings a real physical world context together with an overlapping layer of augmented, virtual information. Augmented reality can be described as combining the real and a virtual world, seamlessly (Dunleavy, 2014; Klopfer & Squire, 2008; Klopfer, 2008; Squire & Jan, 2007; Tscholl & Lindgren, 2014; Yoon & Wang, 2014; Yuen, Yaoyuneyong, & Johnson, 2011). It allows an individual to become fully engaged within a real environment, while being simultaneously engaged with associated augmented virtual items such as people, images, videos, websites, avatars, and/or 3-D objects (Dunleavy, Dede, & Mitchell, 2009; Klopfer & Squire, 2008; O’Shea, Mitchell, Johnston, & Dede, 2009; Yuen, Yaoyuneyong, & Johnson, 2011).

Salmon and Nyhan (2013) describe AR as a ‘wow-factor’ that is required to meaningfully engage, teach abstract concepts, and facilitate collaboration and creativity (Yuen, Yaoyuneyong, & Johnson, 2011). Augmented reality holds promise for learning around an authentic problem-like never before, especially with the use of mobile devices (Holden, 2014; Martin, Dikkers, Squire, & Gagnon, 2014; Tscholl & Lindgren, 2014). AR has several advantages, such as seamlessly overlaying and supporting interactions with digital content with the physical world and viewing content from different perspectives (Asai, Kobayashi, & Kondo, 2005). Dunleavy and Dede (2014) and Dunleavy (2014), define two types of AR: location and vision-based; the current case study utilized vision-based augmented reality. In vision-based augmented reality, the augmented content is displayed by pointing the camera on a mobile device towards an object (QR code, 2-D image, or object) in order to “scan” it.

As time progresses, AR is becoming a technology that is being used in everyday life (Yuen, Yaoyuneyong, & Johnson, 2011). However, according to the Horizon Report (2012), augmented reality will become popular and ubiquitous in four to five years (Johnson, Adams, &
Cummins, 2012; Johnson, Smith, Willis, Levine, & Haywood, 2011). Currently, it has been used in areas of advertising, architecture, entertainment, and medicine (Yuen, Yaoyuneyong, & Johnson, 2011). Augmented reality has been explored in education, and several studies have been implemented that combine mobile devices and augmented reality as tools for language development with English language learners (Chen, Teng, & Lee, 2011; Cheng, Hwang, Wu, Shadiev, & Xie, 2010; Liu & Chu, 2008; Liu, Tan, & Chu, 2007; Liu, Tan, & Chu, 2010; Otaga, Chengui, El-Bishouty, & Yoneo, 2010).

**Augmented Reality as a Tool for Language Learning**

Liu, Tan, and Chu (2007, 2008, & 2010) developed several case studies that explored location-based augmented reality. These researchers used a PDA with UTool software, AR Tool kit, Wi-Fi, and 2-D barcodes to create the “handheld English language learning organization, HELLO” (Liu, Tan, & Chu, 2010, p. 38). Throughout these studies, researchers developed several activity stages for students to complete. University and junior high students followed a campus map and scanned 2-D barcodes outside of classrooms. When a code was scanned students could practice typically occurring vocabulary and conversation with a virtual tutor for a specific space. Findings showed the mobile game motivating for students were easy to use and helpful to learn language. Researchers claimed that by combining augmented reality and a mobile device could be a useful tool to provide students with context-aware learning opportunities.

Cheng, Hwang, Wu, Shadiev, and Xie (2010) had similar findings with their game, *Student Partner*. Ten university students investigated the campus using *Student Partner*. Students shared asynchronous messages and provided feedback to each other. Students reported the system to be helpful, motivating, and easy to learn English in a real environment.
Otaga, Chengui, El-Bishouty, and Yoneo (2010) conducted another study that used AR on a mobile device. Researchers attached radio frequency identification (RFID) tags to everyday objects. They studied the influence of the RFID tags on language learning with an RFID tag reader and writer and a Toshiba Genioe with Pocket PC. This investigation was conducted over two days with eight Japanese and eight non-Japanese students. Results demonstrated on a questionnaire that the RFID tag system was successful for language learning.

Chen, Teng, and Lee (2010) proposed a tool to scaffold learners while reading a printed selection from the *Secret Garden* using a Smartphone. Researchers used quick response (QR) codes printed on the page. A QR code is a 2-D black and white code that is programmed to link to a URL, image, audio, or video. The QR codes used in the study linked to related information such as audio, videos, multimedia pieces, and two-dimensional images. By providing students with these types of supplemental supports, students could gain prior knowledge necessary for the reading activity (Chen, Teng, & Lee, 2010).

Chen, Teng, and Lee (2011) expanded their work of using AR to scaffold learners while reading. Researchers used QR codes printed on reading materials. These codes assisted students in gaining prior knowledge related to concepts in the text. Researchers used a quasi-experimental design with 77 university students for approximately 90 minutes. Students were randomly assigned to four groups. The first group used the printed reading material with the QR codes and scaffolded questions. The second group used the printed material and QR codes. The third group of students used the printed reading material without QR codes, but had the scaffolded questions. The last group had access to the printed reading material. Researchers selected and adapted two sections from the students’ textbooks. Students completed a pre- and post-test as well as a questionnaire to indicate their experience with the AR activity. Researchers found that access to the digital content via the QR codes did not help students in a significant manner. However, access to the scaffolded questions helped students outperform those who did not have access to
the scaffolded questions. Researchers also found students claimed there were too many QR codes printed on the page, and in order to scan them, the phone had to be at a specific angle.

Although these studies focused on comprehension skills, the current study used some questioning prompts. The current study also used resources that are available to students through the internet, such as videos, multimedia tools, and 2-D images. In place of QR codes, marker-less image-based augmented reality was used. Using vision-based AR removed the need to adapt the already printed text and did not require the use of QR codes.

In the area of science, mobile devices have been used as tools for learning in informal learning spaces. These informal learning environments included: gardens, butterfly farms, arboretums, museums, science centers, forests, playgrounds, lakes, and watersheds (Chen, Kao, Sheu; 2003; Chen, Kao, Yu, & Sheu, 2004; Chen, Kao, & Sheu, 2005; Dunleavy, Dede, & Mitchell, 2009; Halpern, Evjen, Cosley, Lin, Tseou, Horowitz, Peesapati, & Gay, 2011; Land, Zimmerman, Murray, Hooper, Sharma, & Mundie, 2011; Rogers et al., 2004; Land & Zimmerman, 2014; Rosenbaum, Klopfer, & Perry, 2007; Squire & Jan, 2007; Squire & Klopfer, 2007; Yoon, Steinmeier, Wang, & Tucker, 2011; Yoon, Elinich, Wang, Steinmeier, & Tucker, 2012; Zimmerman & Land, 2014; Zimmerman, Land, McClain, Mohney, Choi, & Salman, 2013).

Although informal, outdoor science-related mobile augmented reality studies are different from the current study, they are considered foundational pieces in the field (Zimmerman et al., 2013). These studies indicated that AR promotes high levels of engagement, supports collaboration, allows students to engage in higher order thinking skills, and permits students to take on roles during game play (Dunleavy, Dede, & Mitchell, 2009; Halpern, Evjen, Cosley, Lin, Tseou, Horowitz, Peesapati, & Gay, 2011; Rogers et al., 2004; Rosenbaum, Klopfer, & Perry, 2007; Squire & Jan, 2007; Squire & Klopfer, 2007; Yoon, Elinich, Wang, Steinmeier, & Tucker, 2012; Yoon, Steinmeier, Wang, & Tucker, 2011).
Presently, there is limited research regarding how augmented reality and a mobile device can be used together with this particular population of students. Some studies use only AR as a vehicle for learning and include topics related to home economics, physical, occupational, and music therapies (Alamri, Cha, & Saddik, 2010; Brederode, Markopulos, Gielen, Vemeeren, & Ridder, 2005; Brooks, Rose, Attree, & Elliot-Square, 2002; McMahon, Cihak, Gibbons, Fussell, & Mathison, 2013; Shen, Ong, & Nee, 2009; Tam, Schewellnus, Eaton, Hamandi, Lamont, & Chau, 2007). Some studies used only mobile devices. However, results indicating effectiveness are mixed. For instance, Retter, Anderson, and Kieran (2013) conducted a study with thirteen, ninth graders enrolled in an introduction to English course. Retter and colleagues (2013) measured and compared the number of words students read per minute, comprehension scores, and vocabulary gains from the fall to the spring semester. Researchers found six students increased their scores, two students’ scores remained the same, and five had decreased scores in vocabulary word knowledge. This could be because as the school year progressed, vocabulary words became more difficult. Researchers also noted improvements in engagement, and a decrease in inappropriate behaviors when using the iPad during reading. In addition, Jameson, Thompson, Manuele, Smith, Egan, and Moore (2012), found the iPod touch device with a flashcard application was equally as effective as paper flashcards to teach vocabulary words to students diagnosed with a cognitive disability. Although this study did not yield significant results, researchers found a small increase in tolerance for more trials using the iPod touch device with some participants.

**Physical Books**

Book reading is a very familiar activity for students to do both in and out of school. Book reading allows children to gain knowledge, further experiences, and develop vocabulary
and comprehension skills (Light & Smith, 1993; Moody, 2010; Ulanoff & Pucci, 2009).

Storybook reading by an adult to a child can scaffold learning by modeling intonation, emotion, and expression during reading (Boyle & Peregoy, 1990). Although most storybook reading is done with physical books, these do have some limitations. Those limitations include: (a) static black and white text, (b) 2-D images, graphs, and/or charts, (c) physical books do not offer an interactive space for learners, and (d) some information may be outdated (Abas & Zaman, 2011; Hill & Hannafin, 2001). Although physical books have limitations, individuals often prefer them because of the texture and sense of holding a book and turning its pages. In addition, physical books are preferred because of their portability, flexibility, weight, and consistent navigation (Chen, Teng, & Lee, 2010; Grasset, Dünser, & Billinghurst, 2008, September).

E-books

On the other side of the continuum is an E-book. An E-book can be described as a portable, dedicated, and digital text reader that is viewed on a dynamic, digital display (Felvégi & Matthew, 2012). It can be viewed on several types of hardware displays such as mobile phones, tablets, and desktop and laptop computers (Larson, 2010). Unlike a traditional physical book, an E-book can provide a user with several accessibility options including: (a) enlarged text, (b) highlighting capabilities, (c) annotation features, (d) interactive features, (e) search capabilities, (f) gaming features, (g) hotspots, (h) text-to-speech options, (i) bookmarking, and (j) dictionary features (Ahlroos & Hahto, 2012; Felvégi & Matthew, 2012; Korat, 2010; Korat & Shamir, 2008; Larson, 2010; Shamir & Korat, 2007; Woody, Daniel, & Baker, 2010). Although these additional features can help learners, they have potential to distract learners from the text (Felvégi & Matthew, 2012; Korat, 2010; Korat & Shamir, 2008; Larson, 2010; Shamir & Korat, 2007). For instance, E-books may include irrelevant animations or inconsistencies between storylines, and
could lead students into passive reading practices (Felvégi & Matthew, 2012; Korat, 2010; Korat & Shamir 2008; Larson, 2010; Shamir & Korat, 2007).

**Augmented Reality Books**

A recent innovation in the area of augmented reality and literacy that has “caught the eyes” of researchers and educators alike is the augmented reality book. AR books are able to tie a physical book and e-book together into one. Augmented reality books are similar to physical books, with the exception that pages in an AR book include virtual content that can be viewed through a device (Abas & Zaman, 2011; Billinghurst & Dünser, 2012; Grasset, Dünser, & Billinghurst, 2008, September; Matcha & Rambli, 2012). However, little empirical data has been collected in this area.

An AR book has three parts: the physical book, a computer, and a device that can display the augmented content (Matcha & Rambli, 2012). Augmented reality enhanced books allow students to explore content that may be above his/her grade level and engage with peers (Billinghurst & Dünser, 2012; Ha, Lee, & Woo, 2011; Hornecker & Dünser, 2007; Mahadzir & Phung, 2013; Singh, Cheok, Ng, & Farbiz, 2004; Yuen, Yaoyuneyong, & Johnson, 2011). Augmented reality enhanced books can supplement students’ reading experience by providing more information through videos, audio clips, images, 3-D objects, and interactive diagrams (Billinghurst & Dünser, 2012; Dünser, 2008; Dünser, Walker, Horner, & Bentall, 2012).

Augmented reality books can be divided into two categories based on their content: *animated* or *static* content (Yuen, Yaoyuneyong, & Johnson, 2011). Another way to classify AR books is based upon their layout (Grasset, Dünser, & Billinghurst, 2008, September). An AR book can have one of three layouts: basic, multimedia side by side, or multimedia integrated (Grasset, Dünser, & Billinghurst, 2008, September). With the basic layout, only the augmented
content is available; textual content is not presented to the user. The multimedia side-by-side layout includes text on one page, and a code on the other. The multimedia integrated layout presents the user with virtual content and the text together as one unified piece (Grasset, Dünser, & Billinghurst, 2008, September). Figure 2.1 shows the physical continuum of a book ranging from a physical book to an E-book.

Figure 2.1. Physical continuum of a book as adapted from Grasset, Dünser, and Billinghurst, (2008, September), Yuen, Yaoyuneyong, and Johnson, (2011), and Matcha and Rambli, (2012).

Augmented reality enhanced books housed on mobile devices can bring together some preferences of a physical book and work through the limitations of the use of augmented reality. For instance, a mobile device has an inherit feature of being transportable, ubiquitous, compact, flexible, and lightweight (Johnson, Adams, & Cummins, 2012; Singh, Cheok, Ng, & Farbiz, 2004). To date, little empirical research has been conducted regarding how augmented reality
books can be used on a handheld mobile device; however it has been suggested by some researchers (Billinghurst & Dünser, 2012; Dünser, Walker, Horner, & Bentall; 2012; Uras, Ardu, Paddeu, & Deriu, 2012). Most AR book studies require an individual to utilize additional computer hardware to access the book, such as a handheld augmented reality display, webcam on a computer, projection display, or head-mounted display (HMD) worn by a user (Asai, Kobayashi, & Kondo, 2005; Billinghurst, Kato, & Poupyrev, 2001b; Dünser & Hornecker, 2007; Dünser, 2008; Dünser, Walker, Horner, & Bentall, 2012; Grasset, Dünser, Seichter, & Billinghurst, 2007; Grasset, Dünser & Billinghurst, 2008, September; Hornecker & Dünser, 2007; Kirner, Reis, & Kirner, 2012; Mahadzir & Phung, 2013; Smith, Luckin, Fraser, Williams, Dünser, Hornecker, Woolard, & Lancaster, 2007; Uras, Ardu, Paddeu, & Deriu, 2012; Woods, Billinghurst, Looser, Aldridge, Brown, Garrie, & Nelles, 2004). Most AR books require individuals to scan a code, AR marker, RFID tag, or use AR paddles to access the augmented content (Asai, Kobayashi, & Kondo, 2005; Dünser & Hornecker, 2007; Dünser, 2008; Dünser, Walker, Horner, & Bentall 2012; Grasset, Dünser & Billinghurst, 2008, September; Hornecker & Dünser, 2007; Kirner, Reis, & Kirner, 2012; Smith, Luckin, Fraser, Williams, Dünser, Hornecker, Woolard, & Lancaster, 2007; Uras, Ardu, Paddeu, & Deriu, 2012; Vate-U-Lan, 2012). One exception is Kao and Shih (2013) who proposed a marker-less AR picture book, using graphics found in the text to augment the content.

**Augmented Reality books using a head mounted display**

Billinghurst et al. (2001a) in Magic Book first proposed the concept of an AR book. The authors purported that if individuals wore an augmented reality display during book reading, they could see the book come to life (Billinghurst et al., 2001a). Magic Book used a handheld augmented reality display, computer graphics, and a physical book. Computer graphics displayed
virtual content on top of a physical book, which was viewed by an augmented reality handheld display. One key aspect was that many people could read the same book. Billinghurst, Kato, and Poupyrev (2001b) showed Magic Book during a conference. About fifty people completed a survey and indicated that magic book was engaging, easy to use and navigate, easy to collaborate, and overall a positive experience.

Asai, Kobayashi, and Kondo (2005) created augmented reality instructions for 22 university students who were enrolled in a science course. Participants read a document with an AR tag printed on it and viewed a 3-D model of caffeine using a handheld PC and a head-mount display (HMD). Asai and colleagues (2005) attempted to determine which AR device was preferred for viewing the content. Researchers found through questionnaires and open-ended comments, that participants preferred using the handheld PC for longer periods. This was due to its high resolution and compact size. However, some individuals enjoyed using the HMD because it was a hands-free tool.

**Augmented reality books with a webcam and computer**

Hornecker and Dünser (2007) developed two augmented reality books with AR paddles identified by a computer webcam. They observed children ages six and a half to seven years old, some labeled as “good” and “poor” readers. Students were placed into groups: six pairs and six individual students read both AR books. The AR books were sheets of paper with codes printed on them meant to interact with the webcam to set the scene. The AR paddles were used to represent characters in the book. These paddles had AR markers or codes printed on paper and attached to handles. These paddles were mobile and lightweight and could be moved across the screen. Researchers found students collaborated with their AR markers. Through observation, they also found after two introductory pages, students did not rely on the scaffolds provided.
Researchers reported students had interactional and navigational issues when using the AR paddles.

Smith and colleagues (2007) developed an AR book using a webcam and AR paddles for 21 students ages five to seven. The first group of 12 students worked in pairs with either an AR book, a flash-media book, or a pop-up book in the classroom. The other group of nine students worked in pairs using the same three types of books, but in a library. Researchers found through videotapes, interviews, and drawings that students who used the AR book had navigational issues and used more trial-and-error techniques, which in turn lead to a more playful interaction. Smith and colleagues (2007) also found that students who used the pop-up book were able to remember more events that happened in the story than those who used the AR or flash-media books.

Another study that found students utilizing trial-and-error techniques with an AR book was developed by Kirner, Reis, and Kirner (2012). Researchers created an augmented reality book that used both text and codes. It was designed to help nine and ten-year-old students learn geometric shapes. Researchers found the books were engaging and students used trial-and-error methods to interact with the book.

Dünser (2008) developed an AR book using a webcam, paper book, and AR paddles. The augmented reality paddles had static black and white AR markers that were recognized by a webcam and linked to content. Twenty-one students between the ages of six and seven participated. Students were put into groups according to their reading abilities: high or low. Students worked either in pairs or alone during a forty-minute session in the library. Dünser (2008) found, based on interviews, students who were labeled as “good readers” could retell more events from the text alone. However, when asked to retell the events based on interactions of the AR paddles, there was not a significant difference between the groups. The researcher concluded that by adding interactive pieces, students who were “poor readers” could recall events from the story.
Vate-U-Lan (2012) developed an AR book using a webcam and RFID tags for third grade students in Thailand studying English. The AR book was designed to help students identify appropriate quotation marks, match vocabulary words, and order the events in a story. Vate-U-Lan (2012) created a quasi-experimental study using individual students, small groups of students, and a simulated large class. All three trials indicated students were excited and increased scores on pre- and – post- tests when using the AR book. However, Vate-U-Lan does not detail the test or in which areas gains were made.

**Augmented Reality books using a projection display**

Uras, Ardu, Paddeu, and Deriu, (2012) developed *Wonderbook*. *Wonderbook* was a fairytale AR book that had several parts: a computer webcam, projector, speakers, and a 14-page book with printed AR codes. Their reasoning behind using this set up was to augment the experience without “invasive” technology. Researchers claimed that their set up made technology invisible to the user. They identified several design features for an AR book by collecting observations, semi-structured interview questions, focus group reports, participant self-reports, and log data. The recommendations include (a) provide at least two input modalities for learners (text, images and video), (b) combine real objects with technology, and (c) use real scenarios. Uras and colleagues (2012) found difficulties with their system. It was not transportable and difficult to calibrate. In the end, researchers considered moving to a mobile device.
Augmented Reality books with an AR handheld device

Woods and colleagues (2004) created two augmented reality book kiosks at a science museum. The AR books had text and a code on each page to trigger 2-D and 3-D virtual content. Researchers observed that users did not read the text in the book. This informed their decision to have text read aloud and ask questions to users when they created their second book. The current case study will expand upon this exploratory observation by including narration and asking questions during the augmentation.

Grasset, Dünser, Seichter, andBillinghurst (2007), used a physical book, computer, handheld AR display device, AR cube, and green screen to augment The House that Jack Built. In the prototype, they incorporated background music, narration, and 2-D and 3-D objects. To promote interaction and collaboration, individuals used the AR cube and a green screen that showed another individual in the book. According to the authors, by enhancing a book with visual and auditory augmented content, and providing different channels to receive input, could help explain a difficult topic or task. The current case study utilized some pieces presented in this prototype including background noise and music, 2-D and 3-D images, and animations.

Later, Grasset, Dünser andBillinghurst (2008, December) created The House that Jack Built mixed reality book, using a handheld AR device. The pages in their book had interactive pieces, ambient noise, 2-D images, and 3-D animations. Users could access the AR content through either a handheld AR device or a webcam. Researchers demonstrated their prototype to 100 individuals at a conference and feedback was positive.

Dünser, Walker, Horner, and Bentall (2012) created three AR books to help high school students learn physics. They posit that by using interaction, students could learn more about the topic. The AR books were about magnetic forces, electromagnetism, and electrical currents. These books used a handheld AR device to view the augmented content. Ten students ages 13 to
15 were randomly assigned to two groups for a between-group comparison analysis. The first group used the AR book and the other group did not. However, both used the same textbook. The researchers hosted three sessions over seven days. Researchers found through pre- and post-tests that students who used the AR book were more engaged and on average, scored higher on the post-test and retention test. Researchers suggest that AR books could help students learn complex material in physics by using 3-D objects.

**AR books for students with special needs**

Several researchers have proposed AR book studies for students diagnosed with special needs. Zainuddin, Zaman, and Ahmad (2009) proposed an augmented reality book in science for 12-year-old students who were deaf. Researchers chose science because it is could be an abstract area for individuals who have hearing impairments. Researchers identified several recommendations for developing AR books: (a) use visual input, (b) utilize 2-D colored graphics, and (c) use short text accompanied with sign language. In addition, Abas and Zaman (2011, July), proposed an AR book for students who were remedial. Researchers suggested using text, audio, and 3-D displays that complement the text (Abas & Zaman, 2011). These suggestions were taken into consideration during the development of the AR books in this study.

With the advent of mobile devices in the field of education, this offers a new platform for augmented reality books. Very little is understood about how students with special needs can use mobile devices with augmented reality. This is a critical research topic to explore, as it brings awareness not only to the field of special education, but works at developing the field of educational technology in research, and designing a study with this population of students.
Chapter 3

Research Methodology

Research questions were explored through a qualitative approach using a case study design (Stake, 2013). A qualitative research approach was selected because it can provide a lens into how the tools selected can help students with their vocabulary attainment skills. Participants in a real world setting bind a case study. It can consist of a group of people, an organization, or just one individual (Bratlinger, Jimenez, Klinger, Pugach, & Richardson, 2005; Glesne, 2011; Kazdin, 1982; Stake, 1995; Stake, 2013). Creswell (2012) describes a case study as an approach that is used by a researcher to explore a real world case or multiple cases over a period of time that involves rich descriptions. More specifically, a collective case study was utilized (Stake, 1995). This approach was selected because I can view each individual and the group of students (Creswell, 2012; Zimmerman, et al., 2013). Students in this study were varied, as each had his/her own specific cognitive characteristics, academic skills, strengths, interests, areas of improvement, needs, social skills, and emotional traits. In addition, a case study approach has been utilized in several augmented reality studies, but with a different population of students (Enyedy, Danish, Delacruz, Kumar, & Gentile, 2011; Klopfer & Squire, 2008).

Research Setting

This research study took place in Pennsylvania, in a small, public, rural school district during the fall 2013 semester. It took place for four weeks between the months of October and November. According to the Pennsylvania State Data Center (2013), the child count for this school district identified 97.5% of the special education students as Caucasian. This school district had approximately 13.5%, or 200, students labeled as requiring special education services.
Given this total, 37.0% of the school population were diagnosed with a specific learning disability (Pennsylvania State Data Center, 2013). Approximately 22% of students in this school district qualify for a free or reduced lunch (Pennsylvania Department of Education, 2013c). According to the Pennsylvania Department of Education district report card (n.d.), the graduation rate of students who require an IEP in this school district is 81% as compared to the state percentage of 71%; both are below the graduation goal of Pennsylvania as 85%.

The study took place in a segregated high school life skills special education classroom. This high school class taught ten students in grades nine through twelve, ages 14-20. In a life skills support classroom, students focus on and practice skills they need for life outside of school; skills they need to be able to independently perform in the community (Cronin, 1996; Friend, 2011). Some of the skills include: functional academic tasks such as money management (counting money and making change) and reading sight and high frequency words. They also include: (a) daily living skills such as safety, (b) relationship skills, (c) survival skills, (d) cooking, (e) hygiene, (f) grooming, (g) pre-vocational skills, and (h) personal needs. Students enrolled in a life skills support classroom can have a variety of diagnoses, including but not limited to: Autism Spectrum Disorders, emotional and behavioral disorders, intellectual disabilities, and specific learning disabilities.

This site was selected because of my previous professional relationship with the high school life skills teacher, Mrs. Fry (Note: pseudonym used). I worked with her as a student teacher in 2006, and we maintained contact. This particular classroom was formerly a home economics classroom, which was converted into a special education classroom. This classroom had several stations: (a) kitchen area (with refrigerator, microwave, oven, counterpace, and cabinets), (b) in front of the kitchen area were two rectangle shaped tables with chairs, (c) technology center (with PC computer, a SMARTboard interactive whiteboard, and two iPads), (d) storage closet, independent student study areas, (e) ten student desks in horseshoe shape
around a whiteboard, (f) library section, and (g) an accessible restroom with changing area. This study took place near the kitchen section at the rectangular table near the doorway. The rectangular table had six chairs around it (one for the teacher, and the rest for the students). Figures 3.1 and 3.2 depict the classroom layout.

Figure 3.1. Displays an image of the back of the classroom

Figure 3.2. Displays the front of the classroom

This setting was selected because it is a natural setting where students participate in reading instruction. Students in these classes range in reading ability, which varied from Pre-
kindergarten through fourth grade. This study focused on students who were reading at a fourth-grade level, which included five students. During a typical reading session, students were guided by their teacher in a small group for approximately 45 minutes. The reading curriculum was selected as it reached each student’s individual need. The instructor typically introduced vocabulary words within the text. Then as a small group students attempt to pair the words with his or her own personal experiences. Reading with the teacher included several activities, which varied based on the text. Because of the wide range of reading abilities in the class, students worked in small groups and individual instruction was provided with several differentiated instruction techniques. These differentiated instruction techniques included: (a) taking turns reading aloud from the text, (b) participating in discussions, (c) answering open-ended questions posed by the teacher, (d) reading silently from the text, (e) reading with partners, (f) worksheets, and (g) using the iPad 2 to search for pictures discussed in the book. The time selected for this study complemented the times when reading was typically conducted in class. Specifically, the study took place during reading class in the high school classroom from 8:00 a.m. to 10:00 a.m. The unit of analysis in this study was the individual students.

Participants

All the students were ages 14-20 and diagnosed with special needs. Students were selected for participation in this research study based on the following criteria: (a) currently struggling in reading, (b) enrolled in the high school life skills special education classrooms, (c) able to hold, operate, and navigate an iPad 2 independently, (d) using the My Sidewalk is on Reading Street textbook as identified by the teacher at the fourth grade level, which was level D, (e) reading below grade level, (f) able to perform fine motor skills, and (g) able to communicate effectively. The selection criteria identified students who were able to demonstrate the
characteristics needed to examine my research question and related sub-questions. The total number of students who fit these criteria was five; however, four consented to participate in the study. The four students who consented to the study included: Nick, Alex, Ava, and Julia (Note: pseudonyms used).

Nick was a fifteen-year-old Caucasian male in the tenth grade. Nick was quiet and reserved, and he would often just answer the questions as prompted by the avatar, with the exception of the last week when he initiated a conversation with the researcher about football. Sometimes he would become distracted if his peers were working in a group, and he was working with the researcher. Nick was cooperative and pleasant. Often when a question was posed, Nick would move around in his chair and fidget with his hands and glasses and repeat sample sentences during all three sessions of one story. Nick was able to successfully maneuver, navigate, and operate the iPad 2 independently. He attended all 12 sessions of the study. During sessions one, seven, and ten, Nick seemed tired because he yawned frequently during those sessions. To finish the augmented reality activity during story one, it took Nick approximately 24 minutes and 11 seconds. He took 17 minutes and 25 seconds to complete story two, 18 minutes and two seconds for story three, and 18 minutes and 33 seconds to complete story four.

Alex was a Caucasian male who was fourteen-years-old and in the ninth grade. During the first session, he did not return his completed parental permission slip. In total, Alex attended eight sessions. During the first day of each book, Alex was relatively cooperative and in a pleasant mood. However, during the sessions that followed, he became bored, tired, and defiant, which was common for Alex. Alex was impulsively disruptive, as he would often talk about concepts unrelated to the topic. Alex was very familiar with using the iPad 2, as he could zoom in and out of the video by pinching the screen, independently navigate, and operate the device, without training. It took Alex approximately 21 minutes and two seconds to complete the activity during story one. Alex completed the activity for story two in about 20 minutes and 27 seconds.
During the third story, Alex completed the activity in approximately 20 minutes and 22 seconds. Alex moved to a different county during the last week of the study.

Ava was a Caucasian female who was fourteen-years-old and in the ninth grade. Ava was the only student who had prior experience using the iPad for reading. She was involved in a pilot study conducted by the researcher during the spring 2013 semester. Ava attended 11 sessions. She displayed cooperative and pleasant behavior. Ava was quiet and would answer questions posed by the avatar. Sometimes she would comment about the glogster page or augmentation. Ava was able to operate and navigate the iPad 2 successfully. Ava’s average time spent on the augmented reality activity during story one was 18 minutes and 23 seconds. She spent about 19 minutes and 30 seconds on story two, 17 minutes and 28 seconds on story three, and 16 minutes and 24 seconds to complete story four.

Julia was a twenty-year-old Caucasian female in the twelfth grade. Julia attended ten sessions. She was typically in a pleasant mood and had a positive attitude during the study. She was verbal and talkative about the books and augmentations. Julia was involved in drama class with typically-developing peers and enjoyed being an “actress”. Julia was absent during session seven due to illness, and was still feeling sick when she came back during session eight. Julia had confidence when she completed the pre and post worksheets, as she would say they were easy. Julia spent about 20 minutes and 33 seconds to complete the augmented reality activity for story one. She spent about 16 minute and 32 second for story two, 16 minutes and five seconds during story three, and 16 minutes and six seconds for the fourth story.

**Materials**

All of the materials in this study were used together to form one tool. The materials that were used in this study included: (a) iPad 2 device, (b) *My Sidewalk is on Reading Street*
Textbook, (c) augmented reality browser (Aurasma), (d) Muvizu, (e) Audacity software, and (f) Glogster.edu.

iPad 2

The iPad 2 used in this study was about nine inches high and seven inches wide, and weighed one and a half pounds (Apple, 2013). The iPad 2 had wireless internet capabilities, camera functionality (rear and front facing cameras), video and audio, and application storage (Apple, 2013). The camera was critical to the study, as the students were using this function to scan for augmented content. This device was selected because it is a handheld, portable device that is readily available to students through the schools.

My Sidewalk is on Reading Street Textbook

The My Sidewalks on Reading Street (published by Scott Foresman) textbook was used during this study, as it was the same textbook that is used by the instructor during class. An actual, physical textbook was selected for this study, because as Billinghurst, Kato, and Poupyrev (2001a) describe, an actual book allows a user to turn pages, read the text without the aid of technology, and look at the images displayed and associated captions. It was selected because the content and structure of the reading textbook would remain consistent throughout the study. It was also a familiar format for students to navigate. The book already contained supports found within it including: highlighted vocabulary words, glossary, images related to content with correlating captions, large text, and a guiding question at the end of each story.

A textbook will be the physical object that is augmented, as it has within it organization, navigation, images, and text that students are already familiar (Asai, Kobayashi, & Kondo, 2005).
One story in the textbook was augmented each week. The stories selected were based on several criteria: (a) interesting to students, (b) was previously read with the teacher, (c) contained at least three vocabulary words, (c) had discernible images on each page for the augmentation, and (d) had a minimum of two pages of textual content. Four stories were selected for use during this study. Below is the text of each story.

**Story 1**

The first was a non-fiction piece about the Southwest. The tile of the text was *Scenes from the Southwest*. This story was four pages long with two pages of textual content. The total number of words in these two passages included 132 words and 19 sentences. According to Microsoft Word 2007, the reading level of this text was at a 2.8 Flesch-Kincaid reading level.

The text is below:

What do you know about the southwest? Do you think it is just a desert? Some parts are arid and sandy. And it is the driest part of the United States. But it also has many other surprises. You can ski down snowcapped mountains. You can hike down deep canyon trails. You can even raft down raging rivers. The southwest is more than just a desert. People who live in the Southwest have a rich history. Native Americans first learned to survive in the southwest. They lived in its canyons and cliffs long ago. Towns grew over time. Cowboys herded cattle. Miners searched for gold. Farmers grew what they could in the hot climate. Towns became large cities. Many towns also died out. Ghost towns and ancient ruins are all that remain.
**Story 2**

The second story was a fictional piece about humans traveling to visit aliens. The story’s title was *Aliens from Idaho*. This story was two pages long with both pages having textual content. The total number of words in these two passages included 146 words and 18 sentences. According to Microsoft Word 2007, the Flesch-Kincaid reading level was at 4.3. The story text is below:

Two-eyed creates come to Midia. Strange creatures known as humans have landed on Midia. The family of humans arrived in this territory sometime between the first and third sunset of this afternoon. They used a strange flying device for their long voyage. These humans gave the Mayor of Midia red fluff they called “flowers”. According to the Mayor, they were not very tasty. ‘Don’t be scared that we only have two eyes. We come in peace’ said a tall human. Dr. Zweeb is a Midian scientist. He recently studied the aliens. He is a great expert on humans. ‘Humans are very simple creates. They come from the plant Idaho. They live underground and eat rocks. They store them in their bodies behind their eyeballs. During winter, the humans grow their feathers and fly. But don’t get them angry. They might blast fire through their noses.’

**Story 3**

The third story was a non-fiction piece about the state California. The title of the text was *California*. This story was two pages long, with both pages having textual content. The total number of words in these two passages included 131 words and 16 sentences. According to Microsoft Word 2007, the reading level of this text was at a 5.4 Flesch-Kincaid reading level. The text is below:
Looking for some unusual vacation photos? Then visit California! California is filled with beautiful sights. But it is also home to some very BIG attractions. California has some of the world’s biggest trees. People have carved some amazing statues out of the giant redwoods. There is a Paul Bunyan statue. It is 49 feet tall! Then there is a house carved from a single log. There is also a gift shop from a tree trunk. In California, you can drive your car through a tree! California is also home to some very big murals. The most famous is the whale mural. It is in Long Beach. It took over 7,000 gallons of paint! At one time it was the largest mural. California has lots of big surprises. Get your camera ready.

**Story 4**

The fourth story was also non-fiction. It was about four national parks: Yosemite, Yellowstone, Denali, and Death Valley. The title of the text was *National Treasures*. This story was eight pages long, however due to time constraints, only four pages were augmented. This story had four pages of textual content. The total number of words in these two passages included 253 words and 36 sentences. According to Microsoft Word 2007, the reading level of this text was at a 5.2 Flesch-Kincaid reading level. The text from the story is below:

Mount McKinley is the tallest mountain in North America. It is 20,320 feet high! It is Denali national park. Visitors to the park can explore forests. And they can see gigantic sheets of ice. They are called glaciers. Dall sheep live here. Grizzly bears live here. And moose live here. It is very cold.” This passage included 54 words in ten sentences. The text on page included: “Death valley is the lowest point in North America. It is 282 feet below sea level. It is also one of the hottest places on Earth. The temperature reached 134 degrees Fahrenheit on July 10, 1913. That is the hottest temperature ever
recorded in the United States! In 1849 miners on their way to the California gold rush named the valley. Yosemite valley looks like a gigantic U. Its rocky cliffs scrape the sky. Huge waterfalls spill over the cliffs. And sequoia trees stand like giants. They are the largest living trees in the world! Black bears roam freely. Big horn sheep also roam freely. Visitors love Yosemite. It is one of our most beautiful national parks.

Yellowstone is America’s oldest national park. Volcanic eruptions and freezing ice shaped Yellowstone. They squeezed and scraped the land. They formed valleys. They pushed up mountains. And they formed huge lakes. The ground below Yellowstone is still hot. Gas and steam bubble up from many spots underground. Researchers predict another volcano will erupt in the future. Yellowstone is a unique park. It is a top spot for visitors.

**Augmenting the content**

The first step in augmenting the content was to take a picture of one image on each page of the textbook: this was the trigger image. A trigger image must have salient features that distinguish it from other images that may be found in the book. A picture of the image in the textbook was taken with an iPad 2 device. Once each image was taken, the image was uploaded to my computer and named accordingly (ex. SFS1 for scenes from the southwest picture one).

**Aurasma**

An augmented reality browser is an application that “display[s] geo-located multimedia content using a virtual representation augmented on the vision of the real world” (Grubert, Langlotz, & Grasset, 2011). Aurasma is a marker-less (image-based) augmented reality browser
developed by the United Kingdom-based Aurasma company in 2011 (Aurasma, 2013). Aurasma uses image and object recognition to link content (Auras). An image is used to trigger the aura once a channel is followed, and trigger images can be used to access additional images, videos, 3-D displays, or links. This augmented reality browser used channels to access the auras created.

To create the augmented content, I first logged into Aurasma with my username and password on my laptop computer. Then I uploaded the trigger images in JPEG format to my channel (“Sam-Test”). I then specified through the program features of the image to key into when augmenting, making the augmentation work and load faster. Once all trigger images were added to the “Sam-Test” channel, I used an invisible overlay. When this overlay was started, it was automatically linked to a glogster.edu page. The glogster.edu page had the video content created from muvizu embedded in it. After each trigger image had an overlay associated with it, I created an aura, which tied all the pieces together to create the augmented content.

When this was completed, the aura was available to view on the Aurasma application. I downloaded the Aurasma application from the iTunes store on the iPad 2 device. Then I opened the application and selected the symbol in the middle of the screen. Then I searched for the “Sam-Test” channel, by clicking on the magnifying glass. When the “Sam-Test” Channel was identified, I selected it and pressed “Follow”, in order to gain the augmented content associated with this channel. When the channel was followed, the images in the reading textbook were ready to be scanned. I tested the images in the textbook prior to working with the students by following the same steps above using the iPad 2 device.

**Muvizu and Audacity**

Muvizu is free 3-D animation software developed by Digimania (Muvizu, 2013). I developed 3-D animated movies of the text. I selected an appropriate scene or background that
enhanced the text. I also added a character to the scene, as the narrator. Then I recorded audio of the text using another free program, Audacity. Once the text was recorded, I uploaded it into Muvizu as a .wav file and assigned that audio clip to the character. When all audio was recorded and assigned to the characters, I added actions to the characters as they read the text. Then I downloaded the movie as a .wmv file, and uploaded the video in glogster.edu.

Glogster.edu

A glog is “…an interactive visual platform in which users create a ‘poster or web page’ containing multimedia elements…” (Glogster, 2013). Glogs can include several elements such as: graphics, images, video, audio, text, links to websites, animations, and drawings. To create a glog for the video content, I logged into glogster by navigating to https://edu.glogster.com/login/. Then I created a mobile webpage from a template. I would then customize the webpage to include a related background for the story. Then I embedded the video into each webpage. The video had several features such as (a) play/pause button, (b) volume control, (c) full screen feature, (d) time elapse countdown, and (e) slider bar to rewind and fast-forward the video. After each video was embedded, I created a button in the lower right hand corner of the page that read “ready”. This was used for navigation to the next page. Once the glog was created, I copied and pasted the URL of the first glog in that sequence into the Aurasma website. The URL was part of an invisible overlay in Aurasma. When the trigger image was activated, the Aurasma application launched the glogster URL. Figure 3.3 depicts a screen shot the augmented content displayed on the iPad 2 using the glogster website.
Figure 3.3. Screenshot of augmented content.

Figure 3.4 displays the overall process of how the augmented content was created to augment each book for the students.

To access this augmented content, students would scan the trigger image with their iPad 2 device. By scanning an image with the iPad 2 device, the Aurasma application recognized the trigger image and linked to the glogster.edu specified URL. The video content on the glogster.edu page was used to expand upon the reading passage and associated vocabulary.
Combined, these tools enriched the students’ reading experience by providing them with explanations of the vocabulary words displayed through video, text, audio, and image supports.

Data collection and analysis

According to Glesne (2011), Baxter and Jack (2008), and Creswell (2012), a case study involves meticulous participant observations, field notes, in-depth descriptions, and interview questions. I incorporated several case study data collection methods into the study which included: (a) student observations before, during and after the activity, (b) non-identifiable field notes of students before, during, and after the activity, (c) video recordings, (d) audio recordings, (e) completed criterion-referenced worksheets both before and after activity (recognition task), (f) completed perceived knowledge of vocabulary word survey before and after the activity, and (g) recordings of prompted verbalizations by the avatar during augmentation (recall task). Data were collected for approximately two hours a day for three consecutive days, (Wednesday, Thursday, and Friday mornings) for four consecutive weeks. Approximately 48 hours of data were transcribed and analyzed. Each data collection method is described below.

Student observations

Observations of students were conducted before, during, and after the augmented reality activity. The sessions were recorded through non-identifiable field notes, along with video recordings of the students participating in the study. I printed one copy of the observation protocol form for each student for each day. Then I placed the protocol in a three-ring binder that held all of the hard copy data documents. The three-ring binder was divided into 12 sections. One copy of the protocol for each student was completed for each session. After each session, I
typed the field notes on my laptop computer. The typed notes were stored in a password-protected file on my personal, home password-protected computer using the My Lockbox software program. The observation protocol is displayed below in figure 3.5.

Student name (pseudonym):
Location: (Describe the physical environment, feel of the classroom):
Date / / 
Time began: _________ Time ended: ________ (Total minutes: ___ )
Story Title:
Session: 1 2 3 4 5 6 7 8 9 10 11 12
Data Collected (highlight all that apply)
• Student observations
• Non-identifiable field notes
• Video recordings
• Audio recordings
• Criterion referenced worksheets
• Perceived knowledge of vocabulary word survey
• Prompted verbalizations
• Spontaneous verbalizations
Observer: Samantha Fecich (SF)
Overview: (What happened during the session):
Before child reads book:
• Student complete perceived knowledge survey
• Student complete criterion reference worksheet
During augmented reality activity:
• Time start:
• Time finish:

<table>
<thead>
<tr>
<th>Page</th>
<th>Notes: Device used to scan (shorthand I= independent, HOH = hand over hand, R= researcher scanned the image), interactions with the augmentation and device, verbal questions/answers both spontaneous and prompted, reactions to the augmentation and device, eye contact with iPad/book/researcher, facial expressions, What does the student use (volume button, reposition device, reposition book)?, How does the student manage both the book and iPad?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>●</td>
</tr>
<tr>
<td>2</td>
<td>●</td>
</tr>
<tr>
<td>3</td>
<td>●</td>
</tr>
<tr>
<td>4</td>
<td>●</td>
</tr>
</tbody>
</table>

After child reads augmented reality enhanced book:
• Student complete perceived knowledge survey
• Student complete criterion reference worksheet

Figure 3.5. Observation protocol
**Video recordings**

Video recordings were selected for use, as they were able to capture students’ verbalizations, behaviors, and associated context (Tochon, 2007). For consented students, I used two cameras to capture the activity. Multiple video cameras were selected as to acquire information from several different perspectives (Miller & Zhou, 2007). A stationary video camera with an integrated microphone on a tripod was aimed at the student reading the textbook. I positioned the student in order to minimize other students from appearing in the video recording. The digital video camera was positioned to the right, pointing at a 45-degree angle at the student as to capture the student and the augmentation on the iPad screen. I began recording at the beginning of each session as students came to the table to work with an augmented book, and continued until all the students were finished. I also recorded student’s faces using my netbook laptop, which was also password protected. I used the windows live moviemaker program and recorded each student using the webcam. I started recording each student when s/he came to the table and then stopped the recording when each individual’s session was over. The files were saved according to the student’s pseudonyms and date. Each video was saved to the desktop of the computer. The videos were extracted from this computer to my other laptop for analysis with a flash drive. Each video recording was transcribed using Microsoft Video player and Microsoft Excel 2007 software for Windows and saved on my personal password-protected computer. I played the video in the video software and obtained time stamps from that program. I then typed the transcript line by line into Microsoft Excel 2007 separated by event.
Audio recordings

Audio recordings were collected to serve as a back-up recording method in case the video cameras failed. This way, I had access to what was said during each session. These recordings were done using an internal microphone on my personal, password protected net-book computer. I recorded the audio following the same procedures as the video recordings, beginning at each session and running through the entire session each day. Audio was recorded using audacity software and saved as .wav files. Students and parents were informed that their name, as well as any identifiable information, was replaced by pseudonyms. All audio recordings were saved using the student’s pseudonyms and date. Any digital data and student work that were collected will be destroyed after ten years of the first recording date.

Criterion referenced worksheet

Data on vocabulary knowledge were assessed via a criterion-referenced vocabulary and definition matching worksheet. According to Nitko and Brookhart (2007), matching activities include three parts: instructions, premises, and responses. Several vocabulary words were listed in a column on the left-hand side of the worksheet, and simplified definitions were listed along the right-hand side of the worksheet. The number of definitions exceeded the number of vocabulary words. The definitions of the vocabulary words were also adapted in order to simplify the definition given by the textbook. Students were required to draw a line from the vocabulary word to its correct definition. The vocabulary terms selected were the same on the pre-and-post worksheet; however, they were not presented in the same order (see figure 3.6 for a sample). Students were given the worksheet before and after each augmented reality-enhanced
textbook activity. The instructions were read aloud to the students by the researcher prior to beginning the worksheet.

Name: ______________________

Instructions: Column A has vocabulary words. Find a definition that bests describes the vocabulary word in column B. Draw a line from the vocabulary word in column A to the best definition found in column B. Each definition in column B can be used once or not at all.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Ethnic</td>
<td>b. Talking to someone.</td>
</tr>
<tr>
<td>3. Dinnertime</td>
<td>c. When we eat dinner.</td>
</tr>
<tr>
<td></td>
<td>d. Tastes good.</td>
</tr>
</tbody>
</table>

Figure 3.6. Sample criterion referenced worksheet

Perceived knowledge of vocabulary words survey

Students were surveyed about their perceived knowledge of each vocabulary word (see Figure 3.7), using methods similar to Jameson and colleagues (2012). On the worksheet below, students wrote an X under the category that best described their knowledge of the vocabulary word. This survey measured their perceived knowledge regarding the selected vocabulary words. This was used to compare their answers on the criterion-referenced worksheet to the answers they verbalized during reading after being prompted by an avatar (discussed more in the section that follows). Prior to giving the students the perceived knowledge survey displayed in figure 3.7, I told students, “These questions are going to tell me what you know about the words on the list. There is no right or wrong answer. Please write an X in the column that best shows what you know about the word. For example, if you have never seen the word, put an X in the column 1. If you have seen the word before and kind of know what it means, put an X in column 2. If you know what the word means, put an X in column 3.” Then I waited for the student to complete the survey.

Directions: Write an X in the column that best describes your understanding of each word below.
Students were prompted to verbalize or “talk” to an avatar by answering different questions. These questions were mostly recall questions where the student was asked to repeat a vocabulary word or definition. The avatar also asked students to provide a sample sentence using the vocabulary word, after the avatar provided an example. A generic format of scaffolding techniques is listed below in figure 3.8.

<table>
<thead>
<tr>
<th>Vocabulary word</th>
<th>I don’t know it, I have never seen this word.</th>
<th>I have seen this word before, and I kind of know what it means</th>
<th>I know this word.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Dinnertime</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communicate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.7. Sample perceived knowledge of vocabulary survey
Figure 3.8. Scaffolding generic format
After data were collected and recorded, all student identifiers were removed for reporting. The data were analyzed through transcripts of video recordings and participant observation field notes. I transcribed the video recordings using Microsoft video player and Microsoft Excel 2007 software. The transcripts were brought together in order to thematically code data into different categories, as per research question. Table 3.1 summarizes the data collection method, as corresponding to each research question.

Table 3.1. Research question, data sources, and data analysis

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Sources</th>
<th>Data analysis</th>
</tr>
</thead>
</table>
| How do students’ spontaneous and prompted verbalizations while using the augmented reality enhanced textbook reflect processing of vocabulary words? | • Non-identifiable field notes of students before, during, and after the activity  
• Transcripts of video  
• Student observations  
• Video recording | • Adapted coding scheme from Zimmerman and colleagues (2013): perceptual, conceptual, learner awareness, unable to answer, connecting, affective, device use, and questioning talk categories. |
| What are the perceived effects of the augmented reality-enhanced book on students’ vocabulary knowledge as measured by a perceived knowledge survey taken before and after the augmented reality activity? | • Completed perceived knowledge of vocabulary word survey before and after the activity  
• Student observations  
• Non-identifiable field notes of students before, during, and after the activity  
• Transcripts of video  
• Video recordings | • Perceived knowledge of vocabulary words from the survey were categorized into three categories: unknown, informed, and known words. |
| What are the effects of the augmented reality-enhanced book on students’ recognition of vocabulary words, as measured by a matching activity of the correct definition on a worksheet before and after the activity and on their sample sentences provided by embedded | • Completed criterion referenced worksheets both before and after activity  
• Prompted | • For each vocabulary word and definition matched correctly, students were given a point. Students’ scores were calculated individually to identify the mean of and post |
questions within the AR book?

- questions provided by the avatar during augmentation
  - Transcripts of video
  - Video recordings
  - Student observations
  - Non-identifiable field notes

worksheet scores.

- Use the Christ, Wang, and Chiu (2011) coding scheme: *unfamiliar, emerging, context-dependent expressive, and unique expressive* as a rubric for their sample sentences

To analyze the question “How do students’ spontaneous and prompted verbalizations while using the augmented reality enhanced textbook reflect processing of vocabulary words?” I adapted a coding scheme based on Zimmerman et al. (2013). This coding scheme included the following talk categories: *perceptual, conceptual, learner awareness, unable to answer, connecting, affective, device use, and questioning*. These categories were used to analyze participant discourse while using augmented reality-enhanced materials. The data included the verbalizations that students provide while processing the reading materials during the augmented reality enhanced book activity. Each talk category is described below in table 3.2.

<table>
<thead>
<tr>
<th>Verbalization Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual</td>
<td>Talk about identification of items in text or augmentation, reading aloud from the iPad screen, and repeating a vocabulary word or definition.</td>
</tr>
<tr>
<td>Conceptual</td>
<td>Interpretations, elaborations, inferences, predictions related to the text or the augmentation.</td>
</tr>
<tr>
<td>Learner awareness</td>
<td>Talk related to (a) self-reflecting, (b) identification if students remembered a definition correctly, and (c) monitoring of their own understanding of a vocabulary word.</td>
</tr>
<tr>
<td>Unable to answer</td>
<td>Talk that showed a student was unable to provide an answer to a question posed by the avatar. It also included identification of not knowing a term or definition, requesting assistance.</td>
</tr>
<tr>
<td>Connecting</td>
<td>Talk that drew a connection between knowledge from outside the text or augmentation or from an earlier reading.</td>
</tr>
<tr>
<td>Affective</td>
<td>Talk that expressed feelings and emotions such as expressions of enjoyment, liking or not liking a portion of the augmentation or the text, and expressions of being bored.</td>
</tr>
</tbody>
</table>
The second research question, “What are the perceived effects of the augmented reality-enhanced book on students’ vocabulary knowledge as measured by a perceived knowledge survey taken before and after the augmented reality activity?” was evaluated through a survey given to each student before and after each augmented reality activity. According to the National Reading Panel report (2000), there are three levels or word knowledge: unknown, acquainted, and established. Durso and Shore (1991) and Shore and Kempe (1999), claim we progress through several stages of word knowledge: unknown, frontier, and known (see figure 3.9).

<table>
<thead>
<tr>
<th>Device use</th>
<th>Talk about technical aspects of the augmentation or iPad.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questioning</td>
<td>Asking clarifying questions about the text.</td>
</tr>
</tbody>
</table>

Figure 3.9. Vocabulary word knowledge progression

This study used an adapted coding scheme informed by Durso and Shore (1991). It used the following word knowledge categories: *unknown*, *informed*, and *known*. The *unknown* words category included vocabulary terms that are unknown to the student. *Unknown* words included words that students recognize as words they do not know or have not seen (Durso & Shore, 1991). *Acquainted* words, or *informed* words, were words that students were able to use in correct situations, but unable to correctly define the word outside of the context of the story. *Informed* words were words in which students are slightly familiar with, and had a basic knowledge of its meaning. The final word category was *established* or *known* words (Durso & Shore, 1991), which included words that were familiar to the student. It required students to be able to identify several meanings of the word, along with being able to use it appropriately in a
sentence. According to Whitmore, Shore, and Smith (2004), information is significant at all three levels of word knowledge. In addition, as we gain exposure to vocabulary words, our knowledge of the vocabulary word is altered (Whitmore, Shore, & Smith, 2004).

The last research question was “What are the effects of the augmented reality-enhanced book on students’ recognition of vocabulary words, as measured by a matching activity of the correct definition on a worksheet before and after the activity and on their sample sentences provided by embedded questions within the AR book?” This research question reviewed data measured via a recognition worksheet (before and after) and students’ sample sentences asked by the avatar book reading. Students’ vocabulary knowledge was analyzed using an adapted coding scheme defined by Christ, Wang, and Chiu (2011): unfamiliar, emerging, context-dependent, and unique expressive. Table 3.3 displayed the adapted coding scheme and associated definitions of each vocabulary word depth category.

Table 3.3 Coding scheme adapted from Christ, Wang, and Chiu (2011)

<table>
<thead>
<tr>
<th>Vocabulary Knowledge Category</th>
<th>Definition of Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfamiliar</td>
<td>unable to provide a sample sentence using the targeted vocabulary word</td>
</tr>
<tr>
<td>Emerging</td>
<td>repeated the sentence provided by the avatar</td>
</tr>
<tr>
<td>Context-Dependent expressive</td>
<td>Sentences were strictly related to the context of the story.</td>
</tr>
<tr>
<td>Unique expressive</td>
<td>Sentences used the target vocabulary in a unique sentence that is not related to the story.</td>
</tr>
</tbody>
</table>

**Procedures**

Prior to beginning the study, I met with Mrs. Fry to discuss which stories in the My Sidewalks on Reading Street textbook would be the best to augment for the students. Together, we identified stories that introduced vocabulary and would be of interest to students. It was critical to select texts that were of interest to students because it could encourage motivation
during reading (Allington, 2005; Graves, Juel, & Graves, 1998). As stated earlier, the stories selected met several criteria: (a) interesting to the students, (b) previously read with the teacher, (c) included at least three vocabulary words, (c) had discernible images on each page, and (d) a minimum of two pages long.

Students were required to have parental consent as well as provide verbal assent to participate in the study. Once the assistant superintendent reviewed the parental consent form, the teacher sent it home with each student who qualified for the study through the school mailing system (See Appendix A for the parental information letter and Appendix B for the parental assent form). Each student was required to return the consent form to their teacher; a one-week deadline was established from the mailing date.

After the parental consent forms were returned, all students whose parents consented to their participation in the study were asked for their verbal assent to participate with a third party witness available (a classroom assistant or personal care aide). Child assent was obtained by first giving each student a copy of the assent form. Then I read the form aloud to each student in the presence of a third party witness. During child assent, I explained to the student that participation is voluntary, and it will not affect his/her grade in class. Each student then verbally indicated “yes” or “no” if they would participate in the study. After the student indicated his/her choice, I wrote their name on the child assent form and indicated the response. I asked the third party witness to sign as well. Additional steps I took prior to the study included making sure the iPad 2 and net-book device were fully charged, had the three-ring binder and pen, obtained a video camera, and tripod that worked properly.

During the first day of data collection, sessions were conducted individually at a station table in a corner of the classroom. During the session, an iPad 2 and a reading textbook were placed on the table in front of the student. I sat to the left of the student with my notebook. I positioned a digital video camera to the right pointing at a 45-degree angle at the student as to
capture the student and the augmentation on the iPad screen. I gained the student’s attention by saying, “Today we are going to read a book with the iPad. Before we do that, we need to complete these worksheets.” Prior to beginning the AR activity, the student completed both the vocabulary knowledge survey and the vocabulary matching worksheet. If needed, I demonstrated how to operate the iPad device. Once completed, I showed the student how to navigate to the Aurasma application by (a) turning on the device, (b) swiping to unlock the screen, and (c) touching the Aurasma icon the screen. When the Aurasma application is running, I demonstrated to the students how to scan an image using the Aurasma browser. First, I showed the student how to hold the iPad over the image. I explained to the student that the image was recognized by the camera and opened a new screen on the iPad that shows a video of an avatar. I told the student that s/he would scan images on each page of the book in order to listen and view the augmented content. I provided hand-over-hand assistance if required by the student. During the augmentation, students needed to respond verbally to questions posed by the avatar. If students did not verbally respond to the question prompts provided by the avatar, a least-to-most prompting hierarchy was used. This least-to-most prompting hierarchy included: (a) verbal, (b) gesture, and (c) modeling prompts (Browder & Spooner, 2011; Cihak, Fahrenkrog, Ayres, & Smith, 2010).

Cihak and colleagues (2010) used a least-to-most prompting hierarchy with elementary students with Autism learning to transition between classes using video modeling on iPods. This study used a similar prompting hierarchy when students did not verbally respond to prompts provided by the avatar. If a student did not respond to the question, I said, “(Student’s name) the avatar asked a question, let’s watch that video again and see if we can answer it.” If a student continued to not respond, a least-to-most prompting hierarchy was used. As suggested by Browder and Spooner (2001), a three-second wait time was provided to students between each step in the hierarchy. This hierarchy included: (a) provide verbal prompt (I repeated the question
posed by the avatar to the student) with three seconds of wait time, (b) provide a gesture and verbal prompt (I pointed to the screen and repeated the question posed by the avatar) and waited three seconds for a response, and then (c) modeled a correct verbal response. When the augmentation activity was complete, the student completed the post vocabulary knowledge survey and vocabulary worksheet. The second through twelfth days followed the same data collection steps listed above.

**Trustworthiness**

Trustworthiness is a way to show that the qualitative research has credibility (Glesne, 2011). To ensure trustworthiness, I used several methods identified by Creswell (2012), which included rich descriptions, using multiple data collection methods and sources (triangulation), spending long periods in the classroom, and building rapport with students.

**Confidentiality and Ethical Considerations**

I entered the classroom as a researcher from Penn State University, and introduced myself to the students, teachers, and related personnel as such. Prior to this study, I developed and completed a pilot test with one of the students who were involved in this study. As a researcher, it was critical to maintain student’s confidentiality, especially because these students were both young and have special needs. This study was conducted under the approval of the Institutional Review Board (IRB) at Penn State University. I protected the confidentiality of the participants in the study by using a pseudonym throughout data collection, organization, storage, and analysis. I created a Microsoft Excel spreadsheet that documented the students’ actual names, corresponding pseudonym, information regarding parental consent, information regarding
child assent by indicating permissions with a Y (for yes) and N (for no), and permission regarding video recording with Y and N. This document was stored in a password protected file on the hard drive of my home computer, which was also password protected. This file was stored in a separate folder on the computer and not located with the other files related to the study.

All digital files were stored within a program called *My Lockbox*. This program required a password to open and did not show the file unless it was activated and given the correct password. All the files in this study (with the exception of spreadsheet) were located in a password protected file on my computer. Within the file, each student had his/her own folder, titled with his or her pseudonym. Within each individual student folder was information for each day, which included non-identifiable field notes, transcripts for the video, raw video footage, audio files, and any images collected. All audio and video files start with date and the recording was made in a similar format (Ex. Ava_2013_03_12_audio or Ava_2013_03_12_video). All hardcopies of student work was documented using their pseudonym and stored in a file folder in my personal desk drawer under lock and key.
Chapter 4

Results

This study explored how an augmented reality book helped students with disabilities with their vocabulary acquisition skills. The results of this study are presented according to each research question and combines the results from each of the four students.

Research question 1

The first question, “How do students’ spontaneous and prompted verbalizations while using the augmented reality enhanced textbook reflect processing of vocabulary words,” was analyzed using the following data sources: non-identifiable field notes, transcripts of videos, student observations, and audio recordings. The data were analyzed using an adapted coding scheme of talk categories from Zimmerman and colleagues (2013): perceptual, conceptual, learner awareness, unable to answer, connecting, affective, device use, and questioning. The chart in figure 4.1 displays the combined summary of each students’ (N=4) coded verbalizations during the sessions.
By conducting a line-by-line analysis of students’ verbalizations during the augmented reality activity, the following patterns of talk related to processing of the AR text were revealed. The perceptual talk category occurred most often with 660 total instances. The perceptual category included the following types of verbalizations: (a) repetition of vocabulary words, (b) repetition of definitions, (c) reading aloud from the iPad screen, and (d) identification of an object or word in the text or augmentation.

The next most frequent category was conceptual talk. This category included 197 occurrences. It included interpretations, elaborations, inferences, and predictions related to the text or augmentation. This category included talk about: (a) what a student knew about a topic, (b) predictions of what the text would be about, (c) student sample sentences, and (d) what a student learned after reading the text.

Device use was the third most frequent category with 153 total instances. Device use talk ranged from (a) comments about the device functionality, (b) questions about navigation, and (c) procedural questioning regarding the device. It included technical aspects of the augmentation or iPad. The unable to answer occurred 59 times. This category included: (a) talk that showed a
student was unable to provide an answer, (b) identification of not knowing a term or definition and (c) requesting assistance.

Next was affective talk and occurred 39 times. Affective talk included language that expressed feelings and emotions related to the augmentations. This category occurred enough to warrant its own coding category. Affective talk included utterances related to: (a) liking or disliking the augmentation or story, (b) expressions of boredom, (c) talk of frustration, and (d) identifying parts of the augmentation as “cool”.

Questioning talk appeared 17 times. The questions posed by students crossed a variety of talk categories. Questions varied from: (a) perceptual questions, (b) self-questioning, (c) text to life questions, and (d) conceptual questions related to the text.

Connecting talk included talk that drew a connection between knowledge from outside the text or augmentation or from an earlier reading. This category had 15 instances.

The learner awareness category also occurred 15 times. Learner awareness included talk related to (a) self-reflecting, (b) identification if students remembered a definition correctly, and (c) monitoring of their own understanding of a vocabulary word.

In summary, the perceptual talk category occurred most often with 57% of the verbalizations. The second most frequent category was conceptual talk with 17% of the verbalizations, followed by device use talk with 13.25% of verbalizations. The unable to answer talk category was next with 5.11% of verbalizations, followed by affective talk with 3.38% of verbalizations. Next was questioning talk with 1.47% of verbalizations. Lastly was connecting talk and learner awareness with 1.30% of the verbalizations. The data in figures 4.2 through 4.5 show each individual student’s categories of talk along with examples from the transcripts.
Nick's verbalizations for each coding category.

Nick had 166 instances labeled as perceptual talk. Most of these utterances were repeating the vocabulary word or definition provided by the avatar. Most of Nick’s verbalizations in the perceptual talk category occurred during the second, third, tenth, and twelfth sessions, with 16 instances each. Examples of Nick’s perceptual talk included:

- Cliff. [Response to prompt asking to say vocabulary word]
- A deep valley with sharp sides. [Response to prompt asking for definition of canyon]
- Kayak in the water. [Response to avatar when asked to name activities in the southwest.]
- There’s flowers. [Identifying a picture in the text]
- Winter wings. [Response to a question prompt provided by avatar]

Conceptual talk had 50 occurrences. Nick’s utterances were mostly related to his predictions and what he learned about the text. Often, Nick’s sample sentences were repeated or were similar across all three sessions of each book. For example, across session four, five, and six Nick identified the exact same sample sentences for voyage and device. These sample sentences included: “I went on a long voyage”, and “I made a big device”. Nick demonstrated
the most instances of *conceptual* talk with six instances during session nine. Some examples of Nick’s *conceptual* talk included:

- You can drive your car through a tree. [Response to what students learned about passage]
- About...prolly about people kayaking in the water. [Prediction]
- I saw a canyon last week. [Sample sentence]
- It has water. [Response to what student knew about topic.]
- Probably about what people do in the southwest. [Prediction]
- There's flowers there. [Identifying what student knew about topic.]

Nick showed three instances of talk labeled in the *learner awareness* category. During session one, Nick had two occurrences during session one and one instance during the second session. Nick’s verbalizations in the *learner awareness* category occurred most often during the first session. These utterances included:

- No I can think of one. [Response to prompt asking for activities that can be done in the southwest]
- No I know. Think of a good one. [Response to creating a sample sentence with *cliff*]
- It's hard to think of {a sample sentence}. [Response to creating a sample sentence with *canyon*]

Nick was *unable to answer* a prompt provided by the avatar 15 times. Most often Nick could not think of a sample sentence or a definition for the word *territory*. Nick’s utterances occurred most often during sessions four and seven. Examples of utterances coded as *unable to answer* included:

- No I don't think.
- I can't think of one for territory.
- I don’t remember.
- Can't think of one.
- I can't think of what the definition was.
- I forgot what it was again.
- I forgot what the question is.
- I don’t know what that is.
Nick demonstrated only one instance labeled as connecting talk. Nick’s verbalization responded to how he knew the topic of the story during session ten. This instance was, “Cause I already read the story”.

He had seven instances labeled as device use. Most of the utterances in this category were related to the volume of the iPad 2. Four out of the seven utterances occurred during session four. His device use utterances included:

- It’s a little too loud. [Referring to volume on iPad 2]
- The whole book {or}? [Asking to scan the whole book or just one page with iPad 2]
- Is it the same video? [Referring to viewing a video on iPad 2]
- Where is the button at? [Referring to locating the next button]
- Why does it do that? [Why video buffers]

Overall, Nick participated in perceptual talk most often. Followed by conceptual, unable to answer, device use, and learner awareness. Nick did not have any verbalizations labeled as affective or questioning talk.

![Alex's Talk category](image-url)

Figure 4.3 Alex’s verbalizations for each coding category
Alex had 153 instances of perceptual talk. Most of Alex’s perceptual talk included utterances related to repeating vocabulary words and definitions. Most occurred during the third session of the activity. Some examples of Alex’s perceptual talk included:

- I see a cactus. I see plants. Someone I see cactus that, that, all those. That's what I see. [Identifying what he saw in the pictures in the text.]
- Arid means very dry. [Defining vocabulary word]
- Unusual means um (Alex pauses video) it means something that is not ordinary. [Defining vocabulary word]

Alex showed the most instances across all students of conceptual talk with 55 occurrences. Alex had the most occurrences of conceptual talk during the second and fourth sessions. Examples of Alex’s utterances labeled as conceptual talk included:

- I learned what cliff means and canyon. [Identifying what he learned from the text]
- I hiked down the deep canyon. [Sample sentence]
- No. I bet in the southwest you can do whatever you want. [Comment about topic]
- I use this device to learn. [Sample sentence]

Alex demonstrated five instances in the learner awareness category. Most of these occurrences were during the third and ninth sessions. Alex demonstrated more learner awareness talk during the third session, which was the last session of book one. A similar instance was during the third book, across session seven, eight, and nine. During the seventh session, Alex had one instance of learner awareness compared to the ninth session where he demonstrated two instances of learner awareness. These two samples show more capability of learner awareness at the end of stories one and three. Both stories were nonfiction pieces. Examples of Alex’s utterances labeled as learner awareness included:

- I know what canyon is.
- It means um let me think.
- Unusual. Let me think on second.
- I remembered it.

Alex was unable to answer a prompt provided by the avatar 18 times. Eight of these responses were provided after asked a perceptual prompt. About seven responses were provided
in response to conceptual questions. Most of the occurrences were during the fifth session.

Examples of Alex’s utterances labeled as *unable to answer* included:

- I dunno.
- I'm not sure.
- I dunno replay the video.
- Well I need help.
- No I don't. I forget.

Alex showed six utterances coded as the *connecting* talk category. Most of his utterances were related to what he did in the reading textbook with his classmates. Alex had the most utterances labeled as *connecting* during the sixth and seventh sessions. Some examples of *connecting* talk included:

- I wonder what it’s like there. I've never been there.
- Yeah we …already read it. [Referring to reading it as a class]
- That’s what we're workin on. [Pointing out a story that the students were reading during class]
- And you can eat the water from a cactus.

Alex demonstrated 21 instances of *affective* talk. Most of Alex’s utterances in the *affective* talk category were negative responses. He had the most utterances during the second session with five total utterances. Alex’s positive responses were during the second session when he was first introduced the augmented reality activity.

- Its soo cool.
- Whoa!
- No I don't. We don't have ta do that page. We can just skip it. It’s not important.
- I’m done.
- Shoot!

Alex had the most verbalizations across all students in the *device use* category with 110 instances. Alex had the most instances of *device use* during the third session, with 25 occurrences. Some examples were:

- Why does it keep on pausin?
- Did I get it? [If the image was scanned properly by the iPad 2]
• It went! [The image linked properly to augmented content]
• What does it say?
• How come it didn’t work before? [Referring to video not playing instantly]

Alex asked 14 questions during the activity. Most of Alex’s questions were conceptual regarding the topic of the story. He asked the most questions during the fifth session, with six utterances. Examples of Alex’s questions included:

• Wait did the southwest used to have guns?
• What’s this? [Points to building in book]
• There’s snow down there?
• Do we live in the southwest?
• What is Idaho anyway?
• Would that be cool if we could do that though?

In summary, Alex had the most utterances labeled as perceptual. The next most occurring talk category was device use, followed by conceptual, affective, unable to answer, questioning, connecting, and lastly, learner awareness.

Figure 4.4 Ava’s verbalizations for each coding category.
Ava demonstrated the most utterances out of all the participants labeled as *perceptual* talk with 199 instances. Most of Ava’s perceptual talk occurred during the twelfth session with 22 occurrences. Examples of Ava’s *perceptual* talk included:

- Umm… I see a cactus, uh flowers, someone who row a boat. [Identification of what student saw in textbook]
- Arid means very dry. [Definition of vocabulary word]
- Um… a tall mountain (makes hand gesture for tall). [Definition of cliff]
- And someone who has four eyes (points to Dr. Zweeb picture in book and makes four fingers hand motion with hand). [Identification of what student saw in textbook]

Ava had 32 instances coded as conceptual talk category. Ava had the most occurrences of *conceptual* talk during the eleventh session, with five instances. Examples included:

- Um… the southwest. [Prediction]
- Hmm (scratches head) I didn't go to the canyon with sharp sides. [Sample sentence]
- … I can water the plants. [What she can do in the southwest]
- … I did not go to cliff. [Sample sentence]
- I learned about I learned about arid, canyon, and (tapped desk twice) cliff. [What student learned about topic]
- My mom uses a device to call on the phone. [Sample sentence]
- Me (points to herself) we carve a turkey for thanksgiving. [Sample sentence]
- Tall statue. 49 feet tall (read from book). [Response to what she learned about topic]

Ava did not show any utterances labeled as *learner awareness*. Often, Ava requested a hint by the augmentation, which was labeled as *unable to answer*. She had 24 instances labeled as *unable to answer*. Ava had the most occurrences of *unable to answer* during sessions four and seven. Examples of Ava’s *unable to answer* talk included:

- Um… (looks at augmentation, yawns) no idea. [Response to what student knew about topic]
- Ummm…Don’t know. [Response to sample sentence]
- Mmm. No Don’t remember. [Response to definition of vocabulary word]
- Um I wanna hint.

Ava did not demonstrate any utterances in the *connecting* talk category. She had 14 instances in the *affective* talk category. Most of these instances occurred during the seventh session, with four instances. Examples included:
• Umm I like the story.
• Ooh I like it. [Points to background image on glogster]
• Eww..[Points to picture of rocks]
• I like that. [Referring to video scene]

Ava had seven instances labeled as device use. Most of these instances were during sessions three, four, and eleven with two instances each. Examples of device use talk included:

• Got it! [Referring to image being scanned]
• That’s weird. [Points to pink and purple background on glog]
• It’s a.. dunno. It’s a beach. [Referring to back background image on glogster]

Ava asked one clarifying question during session eleven which was coded as questioning talk. The question was, “Hottest place on Earth?” She was clarifying what was being asked of her, which was to identify the hottest place on Earth as described in the reading passage. Overall, Ava participated in the perpetual talk category most often. The next most frequent category was conceptual, which was followed by unable to answer, affective, device use, and questioning talk categories. Ava did not demonstrate any utterances of learner awareness or connecting talk during the activity.

### Julia's Talk Category

<table>
<thead>
<tr>
<th>Talk Category</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual</td>
<td>160</td>
</tr>
<tr>
<td>Conceptual</td>
<td>140</td>
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<tr>
<td>Learner awareness</td>
<td>80</td>
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<td>Unable to answer</td>
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<td>Affective</td>
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<td>Device Use</td>
<td>0</td>
</tr>
<tr>
<td>Questioning</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 4.5 Julia’s verbalizations for each coding category

Julia showed 142 instances labeled as perceptual talk. Most of the occurrences of this category were during the third session, with 20 instances. Some examples of Julia’s perceptual talk included:

- I see buildings, and lights in there (points to building). Which they do have electricity.
- Very dry. [Definition of arid]
- Territory. [Repeating a vocabulary word targeted by the avatar]

Julia demonstrated 60 instances of conceptual talk. Most of these occurrences were during the first session, with 10 instances. These instances included:

- We learned I learned that there {there} are cattles. [Points to picture in book]
- A cliff is something you fall off. [Response to definition of cliff]
- Ummm like maybe ride a horse. [Activity student could do in southwest]
- Very dry, it has a canyon, and (lists on fingers) oh what was the other word? Hmm and it doesn’t rain. [Response when asked what she knew about topic]

Julia had seven instances coded as learner awareness. Most occurred during the fifth and ninth sessions. Julia had two instances of learner awareness during session four and one instance during session six. She also had more learner awareness talk during the last session of book three. Julia had two instances of learner awareness during the ninth session. During book four, Julia had one instance during sessions eleven and twelve. Examples of learner awareness included:

- That was hard to remember.
- I can't believe I had that memory in the back of my head (points to head).
- I remembered that!

Julia illustrated two instances of the unable to answer talk category. These instances occurred during the first and fourth sessions. One example of Julia’s unable to answer category is below:

- I forgot.
Julia had eight utterances placed into the connecting talk category. Most of the utterances occurred during the first, fourth, and ninth sessions, with two instances each. Some examples of Julia’s connecting talk included:

- I’ve never been on a cruise but I wish I could go on one. [Response to make a sentence with voyage]
- We were talking about the west last week. But now we are talking about aliens.

Julia demonstrated four instances of affective talk. The most instances of affective talk occurred during the tenth session. Some examples of affective talk included:

- That’s pretty neat.
- That’s pretty cool.
- It looks pretty neat.

Julia showed 29 instances of device use talk. Most of Julia’s device use talk occurred during session eight. Examples included:

- Hmm …oops! [Julia made the video full screen]
- Oops! [Aurasma application appeared]
- The ready button [Points towards ready button]
- Is this the same one or different? [Referring to video]

Julia asked two questions during the activity. Julia asked one question during session one and session four. Her questions were both self questioning in nature, and included:

- Uh what is a territory?
- Hmm (fixes hair) what do I know about the southwest?

Julia participated in the perceptual talk most often. This talk category was followed by conceptual, device use, connecting, learner awareness, affective, unable to answer and lastly, questioning.

By looking across all students, we can see that they all participated in the perceptual talk category most often, followed by conceptual talk. These findings were similar to Zimmerman and colleagues (2013) who also found the perceptual talk to be most common, followed by conceptual talk. The students participated in the perceptual talk category most often with over
half the responses being coded in this category. This could be because most of the prompts were aligned with this level of processing. For instance, across all four stories, 115, or 64%, of the prompts scaffolded perceptual types of responses. Often, students were prompted to recall vocabulary words, definitions and/or to identify objects found in the text (i.e., responses that align with perceptual levels of text processing).

The second most frequent talk category was conceptual with about 17.06% of the utterances. This could be because 61 of the prompts, or 34%, prompted for conceptual information across all stories. Some prompts provided by the avatar required a prediction, identification of what a student knew about the topic, or what a student learned about the topic. Lastly, connecting prompts occurred the least with only 15 instances or 1.30% of the occurrences. This could be due to the fact that only three, or 1.67%, of the prompts were categorized as linking to knowledge or experiences.

**Research question 2**

The second research question was, “What are the perceived effects of the augmented reality-enhanced book on students’ vocabulary knowledge as measured by a perceived knowledge survey taken before and after the augmented reality activity?” The data from the perceived knowledge survey for each student were coded into three categories: unknown, informed, and known words. On the perceived knowledge survey, students who marked a vocabulary word in the “I don’t know it. I have never seen this word” were labeled in the unknown category. Students who marked a vocabulary word in the “I have seen this word before, and I kind of know what it means” column was labeled in the informed category. Lastly, students who placed in X in the column of “I know this word” were labeled in the known category. Data from each student were brought together into one chart, as depicted in figure 4.2 below.
Figure 4.6 Total number of times students marked vocabulary words on their perceived knowledge survey as unknown, informed, or known before and after the augmented reality activity.

This figure shows all four students’ perceived knowledge before and after the augmented reality activity. It depicts that students identified vocabulary words more often in the unknown category before the augmented reality activity than after the activity. For example, 80% of the vocabulary words or 16 instances were marked in the unknown category prior to the activity; only 20% of the vocabulary words or four instances were marked in the unknown category after the activity. Ava had the most instances in the unknown category prior to the activity with nine instances. Nick demonstrated four instances of vocabulary words in the unknown category and Alex had three instances in the unknown category. After the activity, Nick was the only student who marked words as unknown. Julia was the only student who did not have any instances either before or after in the unknown category.
According to the data, students were also more likely to choose the *informed* category after the augmented reality activity than before. More specifically, students marked 45.79% of the vocabulary words or 49 instances in the *informed* category before the activity. Consequently, they and marked 54.21% of vocabulary words or 58 instances in the *informed* category after the activity. Nick had the most instances of marking vocabulary words as *informed* before the activity with 25 instances, followed by Ava with 24 instances. After the activity, Ava marked the most vocabulary words as *informed* with 33 instances, then Nick with 25 instances. Interestingly, Alex and Julia did not mark any vocabulary words in the *informed* category before or after the activity.

In addition, students labeled the *known* category slightly more often after the augmented reality activity than before. For instance, students marked 47.41% or 55 of the vocabulary words in the *known* category before the activity. Compared to 52.59% of the vocabulary words or 61 instances in the *known* category after the activity. Prior to the activity, Julia had the most instances marked in the *known* category, with 30 instances. Alex had 21 instances in the *known* category prior to the augmented reality activity and Nick had four instances. After the activity, Julia had 30 instances in the *known* category, Alex had 24 instances and Nick had seven instances. Interestingly, Julia marked all vocabulary words as *known* both before and after the augmented reality activity for all four stories. In addition, Ava did not mark any vocabulary words in the *known* category before or after the activity. Alex was concerned about the worksheet being a test or counting as grade, as evident in his transcript below. This occurred prior to the perceived knowledge survey before the augmented reality activity:

19. Alex: Is this a test?
20. SF: No. It’s just a worksheet. It does not affect your grade or anything
35. Alex: Wait. Wait did you will you test me on this?
36. SF: No we are not this is not a test. This is not for a grade.
Alex was also concerned about answering correctly after he identified the vocabulary word’s definition. In the example below, Alex previously answered what the word *canyon* means, and he wanted to know if he was correct.

264. Alex: Wait a sec. Am I right?
265. SF: What?
266. Alex: Was I right?
267. SF: You’ll see.

Figure 4.7 demonstrates all students’ observed knowledge of each vocabulary word during the augmented textbook activity for all stories using the *known, informed, and known* categories. Only students’ definitions and sample sentences at the beginning of the activity for each vocabulary word in the transcripts were analyzed. Further, Tables 4.8 through 4.11 show each individual student’s percentages of perceived knowledge.

![Total percentages of perceived knowledge for all students](image)

Figure 4.7 Displays the total percentages of the perceived knowledge categories for all students
The data above show the unknown, informed, and known categories for all students during all four readings. The unknown category included instances where students were unable to provide a definition of the vocabulary word and unable to give a sample sentence. This did not occur during any of the twelve sessions. All students were able to give partial definitions or full definitions and or sample sentences during all sessions.

The informed category data showed several levels of knowledge from a lower level to a higher level. For instance, levels of informed knowledge included: (a) partial definitions and sentence was not provided, (b) a partial definition and a sample sentence were provided, (c) correct definition was provided but a sample sentence was not provided, and (d) no definition but a sample sentence provided. The informed category had 28 instances.

The known category also had several levels, ranging from low to high. These levels included: (a) correct definition, (b) repeated a sentence provided by the avatar, (c) correct definition, but repeated a sentence provided by the avatar, and (d) appropriate definition and his or her own sample sentence was given. The known category had 94 instances.

Nick

![Nick's total percentages of each perceived knowledge category](image)

Figure 4.8 Nick’s perceived knowledge categories according to transcripts
Nick did not have any instances coded as unknown. He demonstrated six instances coded as informed. The example below shows an excerpt from Nick’s transcript from the first session.

In the excerpt, Nick gives the correct definition of arid but he could not provide a sample sentence for arid.

28. SF: So let’s see if we can make a sentence with the word arid.
29 Nick sits in chair and moves from side to side
30. SF: So what did arid mean again?
31. Nick: Very dry
32. SF: Good.
33. SF: What what’s very dry? What could be very dry?
34. Nick: Place that does rain that much.
35. SF: Yeah. So what would that be? So something is very dry it means it's ....
36. Nick moves in chair.
37. SF: What kind of place is really dry?
39. SF: Mm hmm. So could a desert be.... arid?
40. Nick: Yes

Nick had the most instances in the known category, totaling 30 instances. Below is an example from Nick’s transcript. The example shows Nick’s definition and a sample sentence for cliff during the first session.

62. Nick: Cliff
63. SF: Good
64. Nick: A high rock
72. Nick: No I know. Think of a good one.
73. SF: Okay.
74. Nick: I saw a big cliff.

Nick demonstrated 83.33% instances coded as known. This meant he was able to define and provide a sample sentence for the targeted vocabulary words 30 times. Nick had 16.67% or six instances in the informed category. Nick did not demonstrate any instances in the unknown category. Delving more deeply into each session, we can see that during the first book, Nick had one instance of informed during the first session. He moved to the known category during session two and remained in the known category across all three vocabulary words.
Nick had one instance in the *informed* category for the word *territory* sessions four, five, and six. However, he was able to define and provide a sample sentence for *device* and *voyage* across sessions four, five, and six. Nick had only one instance coded in the *informed* category, he was able to define *unusual* but unable to provide a sample sentence during the seventh session. He was able to maintain a definition and sample sentence for *mural* and *carve* across sessions seven, eight, and nine. Nick was able to define *eruption* but could not provide a sample sentence for *eruption* during the tenth session. However, during the eleventh and twelfth sessions Nick could provide a definition and sample sentence for *eruption*. He was able to define and provide a sample sentence for *gigantic* and *carve* during sessions ten, eleven, and twelve.

Alex did not have instances coded as *unknown*. He demonstrated two instances in the informed category. Below is an excerpt from Alex’s transcript during the second session, which demonstrates he could properly define, *arid* but was unable to provide a sample sentence when
prompted by the avatar. Note, although this was labeled as the second session, this was Alex’s first session.

19. Alex: Very dry.
20. SF: Good.
[Prompt provided by avatar: *Arid means very dry. For example, the desert is arid, because it doesn’t rain very much there. Now it is your turn, make a sentence with the word arid.*]
21. Alex: Hmm.
22. Alex: I dunno.

Below is another excerpt where Alex was able to define the vocabulary word *device* but, unable to provide a sample sentence. This instance occurred during session five.

81. Alex: A *device* is a machine that uses is for specific purposes.
82. Alex: I used a {I used a I used a} car *device* to…
83. SF: A card *device*?
84. Alex: No {shook head no, from left to right}.
85. SF: Or a card *device*?
86. Alex: A car.
87. SF: To what?
88. Alex: To travel. To no I used a flying *device*.
89. SF: Used a flying one.
90. Alex: To travel to Michigan.
91. SF: To Michigan?
92. Alex: I didn’t really use a flying *device*.
93. SF: You didn’t?
94. Alex: {shook head no, from left to right}. I just made it up.

Alex had 22 instances in the *known* category. Below shows an excerpt from Alex’s verbalizations during the second session. He was able to provide a definition and sample sentence for *canyon*, but he repeated the sample sentence provided by the avatar.

39. Alex: *Canyon*.
40. SF: Mm hmmm.
41. Alex: A deep valley with sharp sides.
42. SF: Mm hmmm.
43. Alex: Bruce hiked down a *canyon*.

During the ninth session Alex defined and created a sample sentence for *carve*. Below illustrates a sample sentence that Alex created on his own. This instance shows that Alex provides a response prior to being asked by the avatar, which possibly shows that Alex was able to internalize this *conceptual* scaffold. This was Alex’s last session.
61. Alex: *Carve* means make something by cutting into it.
62. SF: Can you please not put your face on the iPad.
63. Alex: Why?
34. SF: Because I don’t want you to.
65. Alex: I saw a wooden statue *carved* out of wood. [Response provided prior to augmentation asking question]

In total, Alex had 91.76% coded in known category. Alex was able to correctly define and provide a sample sentence for the targeted vocabulary words 22 times. He had 8.33% of the instances coded as belonging to the *informed* category. He was able to provide a partial definition or sample sentence twice. Alex did not provide any instances coded as *unknown*.

More specifically, Alex was able to define *arid* but unable to provide a sample sentence during the second session. However, during the third session he was able to define and provide sample sentences for each vocabulary word: *arid, canyon,* and *cliff*. During the fourth session, Alex was able to provide a definition and sample sentence for *territory, voyage,* and *device*. During the fifth session, Alex could not provide a sample sentence, but could give a definition for *device*. He could define and provide a sample sentence for *territory* and *voyage*. During the sixth session, Alex could provide a definition and sample sentence for *territory, voyage,* and *device*. During sessions seven, eight and nine Alex could provide a definition and sample sentence for *unusual, carve,* and *mural*.

Ava
Ava did not demonstrate any instances of the unknown category. However, Ava did illustrate 12 instances coded as informed. Below is an excerpt from a transcript during the first session. In this example, Ava is able to provide a partial definition for canyon and unable to provide a sample sentence.

30. SF: Okay.
31. Ava presses ready button
32. Ava presses play on video {announcement plays and bell rings}
33. Ava: I dunno.

Ava displayed 20 instances in the known category. Below is an example of one of Ava’s utterances coded as known. It shows Ava’s ability to define arid and provide a sample sentence.

11. Ava: Um. Very dry
12. SF: Mm hmm.
13. Ava presses ready button four times
14. SF: Go ahead.
15. Ava presses ready button one time.
16. SF: Click on the word ready {gestures toward word}.
17. Ava presses ready button.
18. SF: There we are!
19. Ava: Presses play on video
20. Ava: Um. Arid means very dry and {inaudible}.
21. SF: And what?
22. Ava: {fixes hair} Very dry.

Over 60% of Ava’s instances were coded as known. Ava could define and provide a sample sentence for the targeted vocabulary words 20 times. She had 37.50% of the instances coded in the informed category. She could give a partial definition and/or a sample sentence 12 times. She did not have any instances coded in the unknown category. During the first session, Ava could provide a sample sentence and partial definition for cliff and canyon. For session two, Ava could provide a partial definition for cliff, but she was unable to provide a sample sentence. Ava was able to provide a partial definition and sample sentence for canyon. Ava could provide a sample sentence and partial definition for cliff during the third session. She was able to provide a partial definition, but unable to give a sample sentence for canyon. Ava was able to properly define arid across sessions one, two, and three.

During the fourth session, Ava was unable to provide a definition for device but could give a partial sample sentence. She was also able to provide a definition for voyage, but could not give a sample sentence. Ava was able to provide a definition and sample sentence for territory. During the fifth session, Ava was able to define device and territory, but could not give a sample sentence. She was able to provide a definition and sample sentence for voyage. During the sixth session, Ava was unable to define device, but provided a sample sentence. In addition, she was able to define and provide a sample sentence for territory and voyage. During the seventh and eighth session, Ava could provide a definition and sample sentence for unusual, carve, and mural. Ava was absent during ninth session. During the tenth and eleventh sessions, Ava could provide a definition and sample sentence for gigantic, eruption, and form. However, during the twelfth session, Ava could define form, but she was unable to provide a sample sentence. She could give sample sentences and define gigantic and eruption.
Julia

Figure 4.11 Julia’s perceived knowledge categories according to transcripts

Julia also did not demonstrate any instances coded as *unknown*. She did have eight instances coded as *informed*. Below demonstrates Julia’s ability to provide a partial definition and sample sentence for *canyon* during the first session.

20. Julia: A *canyon* a very large mountain with sides.
21. SF: Okay. Lets click on that ready button.
22. Julia presses play button on video.
23. Julia: I went to the *canyon*.

Julia demonstrated 22 instances of the known category. In the excerpt below Julia was able to give a correct definition and sample sentence for *arid* during session one.

7. Julia: It means dry. {Makes a gesture with hands, palms facing in towards chest and pushing out} Very dry.
8. SF: Mm hmm
9. SF: Go ahead.
10. Julia: Hmm {rubs nose}. The desert is very *arid*.
Julia had over 73% of her instances coded as known. Julia was able to correctly define and provide a sample sentence for the targeted vocabulary words 22 times. She had 26.67% or eight of the instances coded in the informed category. Julia did not show any instances in the unknown category. Julia was able to give partial information for canyon and a sample sentence during sessions one and three. In addition, Julia was able correctly define and provide a sample sentence for cliff and arid. Julia was absent during the second session. Julia was able to provide a partial definition and sample sentence for territory and device during the fourth session. During session five, Julia provided partial information and a sample sentence for device. She was able to properly define territory and voyage. During session six Julia was able to define territory, voyage, and device. Julia was able to correctly define voyage across sessions four, five, and six.

Julia was absent during session seven. During sessions eight and nine Julia was able to provide partial definitions and a sample sentences for carve. She was able to define and provide sample sentences for unusual and mural during both sessions. Eight and nine Julia was able to give a partial definition and sample sentence for eruption. She was able to correctly define and provide sample sentences for gigantic and form. During the eleventh and twelfth sessions, Julia could provide a correct definition and sample sentence for gigantic, eruption, and form.

Although their perceptions of vocabulary knowledge did not always match what was reflected in the transcripts, students’ perception of vocabulary knowledge did move in a positive direction. For example, prior to the activity students marked vocabulary words as unknown more often prior to the activity than after the activity. In addition, students marked vocabulary words in the informed category more often after the activity than before the activity. In addition, students were more likely to mark vocabulary words as known after the activity than before the augmented reality activity. According to the student’s transcripts of their definition and sample sentence data, students did not demonstrate any verbalizations labeled in the unknown category. Students had 22.95% or 28 instances of their verbalizations coded in the informed category.
Lastly, students had the most verbalizations in the known category, with over 77.05% or 94 instances. These data shows that all students were able to define (or partially define) a vocabulary word and/or provide a sample sentence.

**Research question 3**

The third research question investigated was, “What are the effects of the augmented reality-enhanced book on students’ recognition of vocabulary words, as measured by a matching activity of the correct definition on a worksheet before and after the activity and on their sample sentences provided by embedded questions within the AR book?” Vocabulary knowledge was analyzed using adapted categories defined by Christ, Wang, and Chiu (2011). This question was analyzed using several data sources including completed criterion referenced worksheets, prompted questions, transcripts of videos, video recordings, student observations, and non-identifiable field notes of students. Each vocabulary word and definition matched correctly was coded with one point. Students’ mean scores on the pre-and-post-worksheets were calculated and displayed in table 4.1. Table 4.1 shows students’ mean pre and post scores on the matching worksheet.

Nick’s mean vocabulary scores on a criterion-referenced worksheet before and after augmented textbook activity for all four stories is shown. Nick did not demonstrate a change in mean scores throughout the sessions. He maintained 100% throughout all of the sessions and vocabulary words. These data show that Nick was able to recognize the vocabulary word and its associated definition on the matching worksheet. Next, Alex’s mean vocabulary scores before and after the augmented textbook activity during stories one through three show that during all three stories Alex was able to correctly match the vocabulary word and its’ associated definition after the augmented reality activity. During all three stories, Alex had an increase in his mean
score from pre to post matching activity. Ava’s mean vocabulary scores for stories one through four show an increase in mean scores on the matching activity from pre to post activity. Julia’s mean vocabulary scores show no change. For stories two, three, and four Julia maintained 100% for all vocabulary words.
Table 4.1 Mean scores of pre-and-post worksheet data for all stories during Stories 1-4

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<th>Session</th>
<th>Mean pre-score</th>
<th>Mean post-score</th>
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<td>3</td>
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</tr>
<tr>
<td>Julia</td>
<td>Session</td>
<td>Mean pre-score</td>
<td>Mean post-score</td>
<td>Difference</td>
</tr>
<tr>
<td></td>
<td>1-3</td>
<td>2</td>
<td>2</td>
<td>No change</td>
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<tr>
<td></td>
<td>4-6</td>
<td>3</td>
<td>3</td>
<td>No change</td>
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<tr>
<td></td>
<td>7-9</td>
<td>3</td>
<td>3</td>
<td>No change</td>
</tr>
<tr>
<td></td>
<td>10-12</td>
<td>3</td>
<td>3</td>
<td>No change</td>
</tr>
</tbody>
</table>

Overall, students either maintained their knowledge of vocabulary words, or increased their scores from before the activity to after the activity. Nick was able to consistently recognize the vocabulary words and definitions across all twelve sessions. However, although he could provide a definition, he was not able to provide a sample sentence for targeted vocabulary words seven times. Alex and Ava both increased their mean scores across the augmented reality stories. Julia also maintained vocabulary word knowledge across all three sessions of each book. She was able to define or provide a partial definition for the vocabulary words nine times.

However, vocabulary knowledge cannot only be measured by matching a definition with a vocabulary word, but also how the student uses the vocabulary word in a sentence. In order to examine vocabulary knowledge more deeply, an adaptation of the Christ, Wang, and Chiu (2011) coding scheme was used. This coding scheme included unfamiliar, emerging, simple expressive,
complex expressive, and unique expressive word knowledge. The sample sentences provided by each student were coded and analyzed using the adapted coding scheme. Figure 4.12 below demonstrates the total percentages of each vocabulary knowledge category for all of the students.

![Total percentages of all vocabulary knowledge depth categories across all students](image)

Figure 4.12 displays all vocabulary knowledge depth categories: unfamiliar, emerging, context-dependent, and unique expressive, across all four students.

The unfamiliar knowledge category was applied to verbalizations where a student was unable to provide a sample sentence using the targeted vocabulary word. There were 15 instances in this category. The emerging category included utterances where the student repeated the sentence provided by the avatar. There were ten verbalizations coded as emerging. The next category was context-dependent. This category was defined as sentences that were strictly related to the context of the story. There were 23 utterances in this category. Unique expressive was the next category. This category was used for sentences that were novel or newly created by the student. Students used the target vocabulary in a unique sentence that was not related to the story. This was the most frequent category and had different levels of sentences from lower to higher-level. The lower-level sentences were novel, in a sense that students changed some part of
the sentence to something different from the example provided by the avatar. This was considered evidence of near transfer. Higher order sentences demonstrated far transfer. There were 74 instances of verbalizations in the *unique expressive* category.

**Nick**

![Nick Vocabulary Knowledge Depth category](chart)

Figure 4.13 Nick’s vocabulary depth knowledge

Nick said six utterances labeled as *unfamiliar*. Some examples of Nick’s utterances labeled as unfamiliar included:

- I can’t think of one for *territory*.
- Can’t think of one.
- I can’t think of one.

Nick did not demonstrate any utterances labeled in the *emerging* category. However, he had two utterances labeled as *context dependent*. Both examples were in response to create a sample sentence with *arid*. The sample sentence was, “The southwest is *arid*.” Nick had the most verbalizations in the *unique expressive* category, with 28. However, most of his instances were at a lower-level. Some examples of Nick’s *unique expressive* sentences included:
- A pumpkin started to form.
- I walked down a cliff yesterday.
- I made a big device.
- I went on a long voyage.

**Alex**

![Bar chart showing Alex's vocabulary knowledge depth category](image)

**Figure 4.14** Alex’s vocabulary depth knowledge

Alex showed two utterances labeled as unfamiliar. Examples of utterances that were labeled as unfamiliar included, “I dunno”. Alex demonstrated the most utterances out of all four students labeled as emerging, with six utterances. Examples included:

- Mural. Oh. I painted a gnarly mural on the wall.
- Bruce hiked down a canyon.

Alex said five utterances labeled as context dependent. Alex’s sample sentences labeled as context dependent were related to the augmentation. For example, Alex responded with the sample sentence “I made a long voyage with a rocket”, after he replayed the augmentation. The augmentation read, “A voyage is a long trip. For example, the humans made a long voyage from
Idaho to Midia. Now it’s your turn, make a sentence with the word voyage.” He would make slight variations to the sample sentences suggested by the avatar. Examples of context dependent sentences included:

- I *carved* a log house. [Augmentation read: Carve means to make something by cutting into it. For example, I saw a statue carved out of wood. Now it’s your turn, make a sentence with the word carve.]
- In the desert it is *arid*. [Augmentation read: Arid means very dry. For example, the desert is arid, because it doesn’t rain very much there. Now it’s your turn, make a sentence with the word arid.]
- That thing {points to picture of log house in book}. This one log house is unusual. [Augmentation read: Unusual is something that is not ordinary For example, I have never seen such an unusual statue. Now it’s your turn, make a sentence with the word unusual.]
- I saw a wooden statue carved out of wood. [Augmentation read: Carve means to make something by cutting into it. For example, I saw a statue carved out of wood. Now it’s your turn, make a sentence with the word carve.]

Alex demonstrated five instances of *unique expressive* and most were categorized as a higher-level. Some examples included:

- Uh *unusual*. Unusual. I've never seen such unusual faces. {Points to the left} Wait. Yeah I've never seen such unusual faces.
- I can't I do not want to fall down a *cliff*.
- Mrs. Fry fell off a *cliff*. {Points with finger towards teacher}
Ava had the most instances out of all four students labeled as unfamiliar with seven. Examples of the utterances included:

- Um. No idea.
- The the {shakes head no}.
- I dunno.

Ava showed four utterances coded as emerging. These examples included:

- Um the humans used a flying device from Idaho to Midia {read off screen}.
- I saw a statue carved out of wood.

Ava had the most utterances out of all of the students labeled as context dependent with 11 instances. Most of Ava’s context dependent sentences were related to the augmentation, which occurred three times, most often for canyon. Ava would also repeat a vocabulary word’s definitions in place of providing a sample sentence, this occurred 8 times. Most often Ava repeated the definition for arid, as her sample sentence which occurred across sessions one, two, and three. Examples of utterances labeled as context dependent included:
- Um The **voyages** takes long trip. [Augmentation read: A voyage is a long trip. For example, the humans made a long voyage from a Idaho to Midia. Now it’s your turn, make a sentence with the word voyage.]
- **Cliff** means you could fall. [Augmentation read: A cliff is a high rock. For example, standing next to a cliff is dangerous you could fall! Now it’s your turn, make a sentence with the word cliff.]
- Umm **arid** means very dry and (inaudible) [Augmentation read: Arid means very dry. For example, the desert is arid, because it doesn’t rain very much there. Now it’s your turn, make a sentence with the word arid.]
- **Mural.** I painted a **mural.** [Augmentation read: A mural is a large picture painted on a wall. For example, I painted a gnarly mural on the wall. Now it’s your turn, make a sentence with the word mural.]
- Hmm {scratches head} I didn't go to the **canyon** with sharp sides. [Augmentation read: A canyon is a deep valley with sharp sides. For example, Bruce hiked down the deep canyon. Now it’s your turn, make a sentence with the word canyon.]
- Ummm **territory** means a land belongs to {to} a country. [Augmentation read: Territory means land that belongs to a country. For example, The territory of Midia has hills and lakes. Now it’s your turn, make a sentence with the word territory.]
- I see a . I see . Um. **Eruption** means lava or steam out of volcano. [Augmentation read: Eruption. An eruption is lava or steam bursting out of a volcano. For example, to see the eruption of lava and steam was amazing. Now it’s your turn, make a sentence with the word eruption.]

Ava had eleven instances in the **unique expressive** category mostly at the lower- level. Some examples included:

- Um I like I did not go to **cliff.**
- My mom uses a **device** to call on the phone.
- Umm I **carved** a pumpkin.
Figure 4.15 Julia’s vocabulary depth knowledge

Julia did not demonstrate any utterances as being labeled as unfamiliar or emerging. Julia said five utterances labeled as context dependent. There were instances where Julia’s sample sentences were related to the augmentation as demonstrated in the examples below:

- The desert is very arid. [Augmentation read: Arid means very dry. For example, the desert is arid, because it doesn’t rain very much there. Now it’s your turn, make a sentence with the word arid.]
- The southwest is arid. [Augmentation read: Arid means very dry. For example, the desert is arid, because it doesn’t rain very much there. Now it’s your turn, make a sentence with the word arid.]
- I saw a volcano erupt. [Augmentation read: Eruption. An eruption is lava or steam bursting out of a volcano. For example, to see the eruption of lava and steam was amazing. Now it’s your turn, make a sentence with the word eruption.]
- the volcano had an eruption. [Augmentation read: Eruption. An eruption is lava or steam bursting out of a volcano. For example, to see the eruption of lava and steam was amazing. Now it’s your turn, make a sentence with the word eruption.]
- I saw a volcano I saw an eruption from the volcano. [Augmentation read: Eruption. An eruption is lava or steam bursting out of a volcano. For example, to see the eruption of
lava and steam was amazing. Now it’s your turn, make a sentence with the word eruption.]

Julia showed 25 instances of unique expressive and she had many higher-level unique sentences. These sentences showed Julia’s ability to demonstrate far transfer her knowledge of the vocabulary word to a novel sample sentence. Examples of the sentences coded as unique expressive included:

- I could fall off the cliff {smiles and fixes hair}.
- I climbed a gigantic building.
- I went on a cruise as my voyage.
- I used a device to check people's hearts.
- I have my own territory.
- I took a long voyage up to my friend's house.
- I carved a pumpkin. {Julia opens hands and uses hand gesture with her palm turned up near chest}
- I saw a cloud forming into a {a} heart.

Some examples of Julia’s lower-level knowledge or demonstrations of near transfer sentences included:

- I saw something unusual.
- I painted a mural of my favorite character ever on the wall.
- I carved a statue.
- I went to a territory.
- I went to the canyon.
- Um I went to see the canyon.

Overall, the unique expressive category was the most frequent vocabulary knowledge category observed in the sample sentences. About 60.66% or 74 the instances were labeled unique expressive. This finding suggests that students were able to create novel sentences using the targeted vocabulary words more than half of the time. Sentences ranged from lower-level to higher-level in the unique expressive category. Context-dependent was the second most frequent with over 18.55% or 23 of the instances were coded in this category. Students were able to create
sentences that were closely tied to the story’s theme. Students were unable to create a sentence 12.30% of the time, or 15 instances, which showed they could not identify a sentence instead of reading off the screen at the emerging level. Students repeated sentences provided by the avatar slightly more than 8.20% or 10 instances, coded as emerging.
Chapter 5
Discussion

This study explored the use of augmented reality books for vocabulary word attainment on an iPad 2 with students diagnosed with disabilities in a high school life skills class using a collective case study approach. This study extended and supported work in the field of augmented reality books by providing educators with a possible design framework supported by research. It also expanded on work conducted by early pioneers of AR books who suggested implementing a mobile device as a method of delivery for AR books (Billinghurst & Dünser, 2012; Dünser, Walker, Horner, & Bentall, 2012; Uras, Ardu, Paddeu, & Deriu, 2012). This study revealed that due to the affordances of mobile devices (portable, ubiquitous, powerful computer size, camera functionality, small size and weight), they are viable options to display for AR books (Holden, 2014; Johnson, Adams, & Cummins, 2012; Pea and Moldonado, 2006; Singh, Cheok, Ng, & Farbiz, 2004; White, 2014).

This study had three related sub-questions, and was guided by the following overall research question: “How does the use of an augmented reality book that is enhanced with layers of conceptual, perceptual, and connecting scaffolds, influence vocabulary knowledge and processing of students who are diagnosed with special needs?” Each research question is listed below along with a brief summary, associated findings, discussion, and implications for design.

**Research question one: Talk Categories**

The first research question was: “How do students’ spontaneous and prompted verbalizations while using the augmented reality enhanced textbook reflect processing of vocabulary words, using a coding scheme adapted from Zimmerman et al. (2013)?” Results
indicated that the perceptual talk category was the most frequently observed followed by conceptual, device use, unable to answer, affective, questioning, connecting, and learner awareness. The perceptual talk category occurred most often, followed by conceptual talk, which is similar to the findings from Zimmerman and colleagues (2013). However, these findings differ with Allen’s (2002) findings that show affective as the second most frequent category after perceptual talk. This could be explained by the context and content used in the current study and in Allen’s (2002) study. Allen’s (2002) work was set in a museum, which differed substantially from a school context. In addition, Allen (2002) used exhibits about animals, and the current study used reading textbooks with the content based on different places. These two reasons could be a likely explanation for a difference in the findings from the current study to work by Allen (2002).

**Implications for Future Research and Design**

The table in chapter 2 depicts the scaffolds that were used during the augmentation: (a) provide simplified versions of the definitions found in the glossary of the textbook, (b) provide image supports that enhance the vocabulary word and its associated definition, (c) use questioning prompts, (d) scaffold vocabulary rehearsal strategies, and (e) provide corrective feedback. The simplified versions of the definitions found in the glossary of the textbook allowed students to remember a definition that was not as complicated as the one in the glossary. The simplified definition as also related to the context of the story. Each definition ranged between two to eight words in length. Also, the simplified definitions were sometimes read off the screen the simplified version of the definition which is shown by Nick during session 7 defining the word carve, “To make something by cutting into it [reads off screen]” This suggests an
affordance provided by the augmented reality content. It was interesting that students never used
the glossary to look up a definition of a word, which is an affordance of a textbook. Instead,
students would rewind or replay the video on the augmentation. This suggests that students
understood that the answer was in the video. In the example below, Alex knew that the
definition as somewhere to be found in the text or the video, but struggled with obtaining the
definition.

209  Alex: I dunno what is a voyage?
210  SF: Do you want a hint?
211  Alex: Tell me.
212  SF: Well let’s go back a territory is a land that belongs to a country.
213  Alex: Yeah
214  SF: Now it’s asking what a voyage is.
215  SF: You can click on the ready button for a hint and it will tell you the definition.
216  Alex: What is it?
217  SF: Click on the ready button it will tell us (gestures towards ready button)
218  Alex: It’s on here isn’t it? (points to word on book)
219  SF: Voyage?
220  Alex: It tells you the uh the device (reads words from book).
221  SF: If you click on the ready button (gestures towards button) it will tell us the definition
   of voyage.
222  Alex: Isn't the definition on here (referring to page in book)?
223  SF: mm emmm (shakes head no)
224  Alex: Really?
225  SF: Really.
226  Alex: Well I need help.
227  SF: Well click on the ready button and it will tell us.
228  Alex: No I don't want to.
229  SF: Well lets go back (flips through notes) you said you made a long voyage with a
   rocket. Doe that help?
230  Alex: I dunno
231  SF: What's a voyage. You made a long voyage with a rocket.
232  Alex Look it aint working (Alex was pressing ready button with finger nail).
233  SF: Please press with your finger.
234  Alex: huh?
235  Alex: Isn't there an answer?
236  SF: Yeah the answer is on the next page.
237  Alex: Fine
SF: Why don’t you want to go to the next page?
Alex: It’s a rocket or somethin. Isn't' it?
SF: Its not a rocket.
SF: Its thinkin. Its goin. (Points to loading button)
Alex: Device.
Alex: Voyage is a long trip. (reads off screen)

The excerpt above clearly shows that Alex had an idea that the definition was embedded within the text of the book. This was not the case. He struggled with not being able to define the word without assistance from the augmentation, where is able to successfully define the word voyage, by reading off the screen of the iPad 2.

The scaffold of questioning prompts was effective in eliciting different types of verbalizations, based on the prompts provided. Varying the prompts provided to the students allows the potential to elicit a range of responses (Molenaar, Chiu, Sleegers, & Van Boxtel, 2011; Rosenshine, Meister, & Chapman, 1996). Azevedo, Cromley, and Seibert (2004), claim that most settings employ one or more of the four types of scaffolds identified by Hannafin, Land, and Oliver (1999). It is possible that if more connecting talk prompts were provided to students, more instances of this category could emerge from the data. Zimmerman and colleagues’ (2013) define connecting talk as a student’s ability to make connections related to his/her own lives. This could be addressed by providing more think-aloud prompts by the avatar as described by Davey (1983). Davey (1983) identifies several strategies to incorporate prompts into a think aloud strategy, but one that could help students with their connecting talk is providing an analogy. Providing students with an analogy may help them link to prior or everyday knowledge around a concept.

Another type of prompt is questioning. Xun and Land (2004) categorize question prompts as (a) asking students to provide novel examples of a concept, (b) questions regarding a process, (c) expanding upon information, and (d) prompting for student reflection. Xun and Land (2004) suggest requiring students to answer the question prompts through technology where their
replies can be stored, retrieved, and shared with others. Based upon the above implications some examples of additional prompts that could be provided in future research include:

- Why is it important to learn about (concept)?
- What did you think of when…?
- What do you know about (concept)?
- This story reminds me of a time when I….
- Have you ever experienced …?
- Have you ever visited…?
- Tell me more about…
- This story is like/not like…
- This part made me feel…
- What do you think about…?
- What is going to happen next?
- How does the concept of (concept here) make you feel?

Lastly, provide corrective feedback. Going back to the affordance of the definition displayed on the augmented reality book, speaks to the students’ ability to gain immediate corrective feedback. When a student was asked to define a vocabulary word, instead of looking in the glossary of the textbook students would either progress to the next video to view the answer, pause the video, and state the answer. This was true most often with Ava when she asked for a hint to define the vocabulary word. It would beneficial to conduct research to provide individualized corrective feedback. For instance, some students were able to define the vocabulary word without the prompt by the avatar providing the definition, and others were unable to define the vocabulary word.

An additional implication is related to the coding scheme used during question one. This study drew out the questioning category as its own category of talk, but some of the questions generated by the students could have been categorized into other associated categories such as: perceptual, conceptual, device use, and so on. In future research iterations, it is recommended to
explore collapsing the questioning category to better refine and delineate categories within the coding scheme.

Lastly, some students were able to internalize the definition prompt provided by the avatar. Sometimes students would read or recite the definition or identify a sentence prior to being asked by the avatar. Below is an excerpt from Ava’s transcript during session seven, she actually performed this behavior eight times during sessions seven, eight, ten, eleven, and twelve.

81. Ava: I saw a statue carved out of wood [before augmentation played Ava read off screen]
98. Ava: Is a large picture painted on a wall. [Ava said definition before video did and read off screen after she paused it.]

**Research question two: Perceived Knowledge**

The second research question was the following: “What are the perceived effects of the augmented reality-enhanced book on students’ vocabulary knowledge as measured by a perceived knowledge survey taken before and after the augmented reality activity?” The data depicted that students identified vocabulary words more often in the *unknown* category before the augmented reality activity than after the activity. In addition, students were also more likely to choose the *informed* category before the augmented reality activity than afterwards. Students also labeled the *known* category slightly more often after the augmented reality activity than before. Results indicated that although students’ perceptions of vocabulary knowledge did not always match what was reflected in the transcripts, students’ perception of vocabulary knowledge did move in the right direction.
Implications for Future Research and Design

This study extended the perceived knowledge concept discussed in work by Jameson and colleagues (2012) which found that students thought that the traditional flashcards were more effective with vocabulary learning than the iPod touch, while teachers perceived the iPod touch to be more effective with vocabulary learning. However, results indicated that both the traditional flashcards and iPod touch were effective in teaching vocabulary words to students with cognitive disabilities (Jameson, et al.). This study found a discrepancy between a student’s perception of vocabulary knowledge and what was demonstrated in his/her transcript during the augmented reality activity. If students were unable to identify their own knowledge of a targeted vocabulary word before the activity, then the student is limited in understanding, which words s/he needs to focus on during the activity. Given this sample, it is unclear as to the effectiveness of asking students their perceptions of what vocabulary they do and do not know prior to reading activity.

Although, students had the most instances of known vocabulary words this was necessarily reflected in their talk categories. For example, all students had more instances of known vocabulary words over informed vocabulary words across all four books. This data suggests that although students knew the vocabulary words and could provide a sample sentence; they did not participate in more conceptual talk during the augmented reality activity. This finding suggests that providing more conceptual prompts could elicit more talk labeled as such.

Research question three: Vocabulary depth knowledge

The third research question examined the effects of the augmented reality-enhanced book on students’ recognition of vocabulary words, as measured by a matching activity of the correct definition on a worksheet before and after the activity and on their prompted sample sentences
provided by embedded questions within the AR book. Overall, students either maintained their knowledge of vocabulary words, or increased their scores from before the activity to after the activity. This finding is similar to Vat-U-Lan (2012) who found students increased their scores on post-tests when using the AR book. Vocabulary knowledge can also be examined by how a student applies the vocabulary word in a sentence. To assess vocabulary depth knowledge, sample sentences provided by students were analyzed using an adaptation of the Christ, Wang, and Chiu (2011) coding scheme: unfamiliar, emerging, context dependent, and unique expressive word knowledge. In sum, the unique expressive category was the most frequently identified in the sample sentences. Results indicated that students were able to create novel sentences using the target vocabulary words more than half of the time.

As stated earlier, vocabulary knowledge is more than just knowing a definition of a term (Montgomery, 2013). Data from this study revealed that although some students may have been able to recognize the definition of a target vocabulary word on the matching worksheet, s/he might not have been able to identify a sample sentence when prompted by the avatar. This finding supports the concept of the need for multiple assessments (McDonald, 2002; National Reading Panel Report, 2000; Nitko & Brookhart, 2007). McDonald (2002) explains the importance of providing a student with multiple assessment techniques in order to assess whether or not s/he has successfully attained a targeted skill. The National Reading Panel Report (2000) describes utilizing several measures in order to evaluate vocabulary knowledge. By providing multiple assessments, students are able to provide different responses that reflect different aspects of their knowledge of vocabulary terms (National Reading Panel Report, 2000). By conducting multiple assessments, an instructor is able to see the whole picture of a student’s learning, and can assess more accurately if a student is on target. For example, the matching activity measured whether or not a student could identify a sample sentence for each vocabulary word. By asking a
student to build upon his /her own knowledge of the vocabulary word to create a sentence, this in turn required the student to recall the definition and apply it to a new situation.

**Implications for Future Research and Design**

Upon reflection of the sample sentence activity, a goal that was not explicitly stated was for students to create their own novel sentences. It is possible the prompts used in this study were not efficient in electing a novel response. Perhaps by providing the students with a more direct prompt asking for a novel sentence would elicit a unique expressive response that could be categorized as a higher-level sentence. An example of this prompt might be, “Now it’s your turn. Make a new sentence with the word (target word here).”

**Possibilities for Future Research**

Based upon this study, future research should investigate the use of varied prompts with less focus on perceptual, and more on conceptual and connecting prompts. It is possible that varying the prompts could balance out the processing talk categories from primarily perceptual to include more conceptual and connecting talk. By applying more focus on these types of talk, the categories could increase the higher-order processing skills.

In addition, this study demonstrated that AR books can be used with students who are diagnosed with special needs as suggested by several researchers (Abas & Zaman, 2001; Zainuddin, Zaman, & Ahmad, 2009). Reviewing the data, two students increased mean pre-and-post matching scores and two students maintained their vocabulary knowledge. In addition, students mostly created sentences in the unique expressive category. This shows that students not only could match a vocabulary word to its proper definition, but also apply what s/he knew about
the vocabulary word by creating a sample sentence. This suggests that although students’ measured gains in vocabulary knowledge varied, when examining students’ ability to apply vocabulary words to novel sentences, vocabulary word learning appears to have occurred. To investigate this claim more fully, future research should embed multiple assessment techniques into the activity that can be recorded, stored, and shared on a mobile device. These multiple assessment techniques could include multiple choice questions, short answer responses, and matching vocabulary words to a definition.

A third recommendation for future research is to omit the perceived knowledge survey. As stated above, it was an unclear measure of students’ perceptions of what vocabulary they knew before and after the activity. One interesting finding that is dissimilar to Woods and colleagues (2004), who observed that students in their study did not read in the textbook, is that some of the students in this study read along with book. This study observed Nick and Julia, consistently reading along with the text. Ava occasionally read along while using the augmented reality book. Lastly, Alex did not read along with the text; rather, he only looked at the mobile device.

Findings from this research also suggest implications for the future interface design of AR books. One consideration for the design process would be to have a hint button. Often students would request help when being asked to define a vocabulary word. If a button was available to provide them with a hint with the definition, this may prove beneficial for students. By having a button on the page directly, this would give students more immediate feedback regarding the correct answer. An additional design consideration would be to provide a repeat button for students who forget the prompt provided by the avatar. Often students rewound the video or asked the researcher if they forgot the prompt. Having a resource for students to press and have the prompt repeated may be beneficial. Another design consideration would be to
include a progress bar to show how much of the book the student has remaining and/or has completed. Sometimes students would ask how much more they had to do, or if they were finished with the videos. By having a progress bar available to students, it could display their progress and may decrease the procedural questions related to time remaining on the activity. A progress bar also gives the students something to focus on. If they know they only have 20% more to do, they can stay focused on the task at hand because they are almost finished with the activity.

**Limitations of the Study**

There were several limitations in this study. The first was that the sample only included students with special needs in one high school class. A second was the small sample size of four students. An additional limitation is related to the practical constraints and scalability of the AR books in the classroom. Although the researcher was familiar with the technology and the AR books were rather easy to produce, it did take a considerable amount of time to create them. Therefore, the design and technologies used in this study may still be impractical for an instructor to create and incorporate AR books into the classroom. Possibly as technology progresses, there could be a less time intensive method to create and implement similar AR books in the classroom.
References


Appendix A

Parental information form

Dear Parents/Guardians:

My name is Samantha Fecich, I am currently a PhD candidate in the learning, design, and technology program through Penn State University. I am at the point in my coursework where I need to complete a research study for my dissertation, related to my area of interest, technology in the classroom. I have developed a study to understand and analyze how an augmented reality browser loaded onto a mobile device (iPad 2) can be used to enhance vocabulary acquisition. The title of this research project is: “Augmented vocabulary skills”. This study is being conducted for research purposes only and is affiliated with Penn State University.

I am sharing this information with you because I need your child’s help to complete this research. I plan on conducting this research in the fall semester in your child’s reading class with Mrs. Fry. I want to take this opportunity to explain what your child will be doing and ensure that in no way will your child or his/her grade be affected by his/her participation or lack of participation in this study. Because your child is in this class, you, the parent or legal guardian, must consent in order for them to take part in this research study.

The main goal of this research project is to understand and analyze how augmented reality and an iPad 2 can be used to enhance vocabulary acquisition. I am hoping that by incorporating the augmented reality and the iPad 2, students will be able to understand vocabulary words as they are related to their reading textbook.

Regardless of whether your student takes part in the research study, instruction will be the same for all the students. The only difference is that students who take part in the study will have the data collected from the research to be included in analysis. Your child’s name and identification will not be tied to my data. All of my reporting will be done in a way that the students’ identity will not be disclosed.

In this packet, you will find a consent form if you would like to have your child take part in this research study, please read the consent form and sign it. Please return it to your child’s teacher. If you should have any questions, please feel free to call me at 412-977-9212 or sjh266@psu.edu

Thank you in advance for your time and consideration.

Samantha Fecich
PhD Candidate in Learning, Design, and Technology at Penn State University
Appendix B

Parental Consent form

Title of Project: Augmented Reality Reading
Principal Investigator’s contact information:

Samantha Fecich  
Penn State University  
106 Haffner Hall  
University Park, PA 16802  
SJH266@psu.edu 412-977-9212

1. Purpose of the Study: The purpose of this research study is to understand how mobile computers (an iPad 2) can be used to help student with their vocabulary attainment skills. 

2. Procedures to be followed: Your child will use an iPad provided by his or her teacher to help him or her read books. Your child will use their current reading textbook (My sidewalks on Reading Street) and read from it as they usually would. The researcher will ask your child to fill out a worksheet to match vocabulary words to their definitions and also a survey that indicates their perceived knowledge of a vocabulary word before and after the activity, each day. Your child will use the iPad to gain information about vocabulary words and to have the iPad read passages aloud to them. This will be repeated for three consecutive days for four consecutive weeks. 

3. Discomforts and Risks: There are no risks in participating in this research beyond those experienced in daily life. 

4. Time/Duration: The research study occurs in your child’s classroom during the morning reading class, three times a week for four weeks. Each week, the researcher will read with your child individually in the classroom (approximately 20 minutes). 

5. Statement of Confidentiality: Your child’s participation in this research is confidential. The data will be stored and secured on the researcher’s home computer under password protection, in a password protected file. Any digital data and student work that has been collected will be destroyed after ten years of the first recording date. In the event of any publication or presentation resulting from this research, no personally identifiable information will be disclosed, unless you initial this form below. The researcher will be the only individual who has access to your child’s name; unless you initial below stating that I can share information with your child’s teacher. All other researchers on the team will only see non-identifiable data. 

_____ I agree that portions of my child’s video-recordings, audio recordings, and photographs may be shown in university classrooms, online university classes, conferences, and publications. 

_____ I agree to allow the researcher to interview my child’s teacher about my child’s performance, academics, and special needs. 

6. Right to Ask Questions: Please contact Samantha Fecich at 412-977-9212 or sjh266@psu.edu with any questions, complaints, or concerns about this research study.
7. Voluntary Participation: Your decision for your child to be in this research is voluntary. Your child is able to withdrawal from the study at any time. Because your child is a minor, you, the parent, must consent in order for them to take part in this research study. If you agree, please sign your name and indicate the date below. You will be given a copy of this form for your records.
I give permission for my child to participate in this research study.

Please print full name of child or children

Signature of Parent / Guardian  Date

Signature of Principal Investigator / Person Obtaining Consent  Date
Appendix C

Verbal Child Assent form

Title of Project: Augmented Reality Reading
Principal Investigator’s contact information: Samantha Fecich
Penn State University
106 Haffner Hall
University Park, PA 16802
sjh266@psu.edu
412-977-9212

Hi! My name is Samantha Fecich and I am a student conducting research at Penn State University. I’m here so I can learn how an iPad 2 can help you with your vocabulary words. We are going to use an iPad 2 while we read your textbook today. You are going to use the iPad 2 to scan pictures in the book. When the picture is scanned, the book will be read aloud to you and explain different vocabulary words on the iPad2. While we read I will be recording using my video camera and laptop computer while you use the iPad 2 to help you read. These video and audio clips might be shown to other people at Penn State. Your participation in this study is voluntary; and will not affect your grade in this class. If you want to be in the study say “yes” if you do not want to me in the study say “no”. You can leave the study whenever you want to.

If you have any questions please ask me.
Child’s name: ________________________________________________________________
Witness signature: ____________________________________________________________
Date: ________________________________
VITA

Samantha J. Fecich

106 Haffner Hall, University Park, PA 16802 | 412-977-9212 | SFecich@gmail.com

EDUCATION

Penn State University 2011-2014
PhD Learning, Design, and Technology
Supporting field: Special Education

Penn State University – World Campus 2012
M.Ed. Instructional Systems
Thesis: Collectively Learning about Autism

Penn State University 2006
M.Ed. in Special Education
Concentration in Augmentative and Alternative Communication
Thesis: Learning with MAK

California University of Pennsylvania 2005
B.S. in Special Education and Elementary Education
Certified Special Education K-12 and Elementary Education K-6

AWARDS

Graduate Assistantship at Information Technology Service Desk May 2013- May 2014

Graduate Assistantship in Instructional Systems Fall 2011 – Spring 2013

Graham Robert Endowed Fellowship Fall 2011 – Spring 2012

Featured in Special Education: Contemporary Perspectives for School Professionals Spring, 2010