

EFFECTS OF AN iPad iBOOK ON READING COMPREHENSION, ELECTRODERMAL  
ACTIVITY, AND ENGAGEMENT FOR ADOLESCENTS WITH DISABILITIES

By

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ACCEPTANCE PAGE

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EFFECTS OF AN iPad iBOOK ON READING COMPREHENSION, ELECTRODERMAL  
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## **Abstract**

The purpose of this study was to investigate the effects of an iPad iBook for adolescents with disabilities. With its release in 2012, the iBooks Author software for the Apple iPad allows classroom teachers to create accessible and engaging textbooks. Leveraging media and interactive widgets, iBooks Author holds promise for delivering content to learners of all needs. However, little empirical research currently supports the iPad as a textbook. In this intervention study, 22 middle school students with disabilities learned to identify and understand features of textbooks. Participants were randomly assigned to one of two cohorts and alternated reading between a traditional textbook and iPad iBook across six science textbook chapters. Using a repeated measures design, quantitative and qualitative data were collected for reading comprehension scores, electrodermal activity, cognitive load, and participant satisfaction. Results indicated no significant differences in reading comprehension scores, electrodermal activity levels, or cognitive load scores. Satisfaction measures indicated students significantly preferred the iPad iBook. Emergent themes from participant interviews, fidelity checks, and task analyses are also discussed.

## **Dedication**

To Michael Bateman:

It felt significant and I felt proud, learning to read alongside you. I fondly remember working through *The Boxcar Children*, chatting about things much greater than books. Our friendship and time together taught me the value of helping others and ignited my love for teaching and learning. Thank you.

## Acknowledgements

*Spoon Boy: Do not try and bend the spoon—that's impossible. Instead, only try to realize the truth.*

*Neo: What truth?*

*Spoon Boy: There is no spoon.*

*Neo: There is no spoon?*

*Spoon Boy: Then you'll see that it is not the spoon that bends, it is only yourself.*

*--The Matrix*

*Why won't you run into the rain and play*

*And let the tears splash all over you?*

*--#41*

To my love Courtney: With you, everything is possible.

To Sloane: I give you my world.

To Duke & Madison: Thank you for teaching me loyalty.

To Mom & Dad, my first teachers: From you I have learned the value of love, family, hard work, and believing in myself. I am proud to be your son.

To Grandma & Grandpa: Thank you for the sincerity that comes from “*I love you.*”

To Brother, my best friend: Thanks.

To Horizon Academy staff and students: Our memories drive my work.

To Greg Weseloh: Thank you for being a supportive friend and colleague.

To Dustin, Andy, Heffy, Kimmel, JCBIII, Samuel D. Winning, Primakow, Noah, Jake, &

lejbug2: Thank you for dominating 8A, P6, and life. ON WISCONSIN!

To BK, Trinh, & Woody: I am. I am me. It is good to be the me that I am.

To Franny, Carrie, Leslie, Kennedy, BB, Susanne, Jake, Marti, Zach, the CRL, and my committee: Thank you for your friendship, support, love, and guidance.

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# CHAPTER I

## INTRODUCTION

From the time disability rights safeguards were signed into law by President Gerald Ford in 1975, the Education for All Handicapped Children Act (EAHCA; 1975), its successors, the Individuals with Disabilities Education Act (IDEA; 1990) and the Individuals with Disabilities Education Improvement Act (IDEIA; 2004), as well as its civil counterpart, the Americans with Disabilities Act (ADA, 1990), have included four predominant outcomes for disability policy. Summarized by Turnbull (2005), these outcomes are (a) equal opportunity, (b) full participation, (c) independent living, and (d) economic self-sufficiency. Together, the various disability laws have purposefully guided the field of education towards turning out generations of children and young adults who are productive, independent, and included in the general education classroom. However, for students living at the margins, namely adolescents both with and without disabilities, often struggle to achieve these outcomes. It is appropriate, then, to view the progress of American education through the lens of the students living at the margins, specifically those with disabilities.

Broadening the goals of EAHCA and IDEA, the No Child Left Behind Act of 2001 (NCLB) not only directed schools to provide an appropriate education for all students, including those with disabilities, it also required schools to measure academic progress of toward an appropriate education. Specifically, through standards-based reform, NCLB required yearly reading and mathematics testing in grades 3-8, with the overriding goal of all students reaching “proficiency” by 2014. Lack of progress could result in a school being labeled as “failing,” potentially followed by major corrective measures like staff firings, and, in some cases, school closings.

A significant change to public education, the No Child Left Behind Act has altered the landscape of American classrooms. Now, rather than the four outcomes serving as primary and sufficient measures for disability progress, the focus has shifted to measuring adequate yearly progress through the use of evidence-based practices. However, since 2001, a plethora of remedies designed to improve public education have been proposed with little empirical research backing their effectiveness.

One important measure of progress, the National Assessment of Educational Progress (NAEP), is administered nationally to 9-, 13-, and 17-year old students (grades 4, 8, and 12, respectively). The NAEP serves as somewhat of a snapshot of current educational achievement levels (U.S. Department of Education, 2013a). Considered the Nation’s Report Card” and the gold standard of standardized assessments, the main NAEP has shown significant improvement over time, but the most recent long-term trends indicate little progress (Strauss, 2010). Although NAEP scores evidenced significant advancement in all ethnic groups from 1971-2008, scores from the most recent data, 2008-2012, are concerning. Namely, as education historian Diane Ravitch noted regarding the long-term assessments, “the scores have been stagnant for every racial and ethnic group and for every age group with the singular exception of Hispanic 13-year-olds and female 13-year-olds” (Ravitch, 27 June 2013; see also Rampey, Dion, & Donahue, 2009; U.S. Department of Education, 2013b). Significantly, within the last decade, five school reforms have attempted to improve student outcomes.

### **School Reform Efforts in Post-NCLB**

Among the array of school reform efforts in the post-NCLB era, five are of particular note: privatization of school choice, commercialization of teacher preparation, the Race to the Top (RTTT) initiative, Common Core State Standards (CCSS), and a broad array of technology

initiatives. Largely supported with public finances and modest bipartisan support, most of these initiatives are not grounded in a solid research foundation, however.

The most recent of these post-NCLB-era reform efforts, technology initiatives, have led to an infusion of technologies into the classroom, mostly recently through the U.S. Department of Education's National Educational Technology Plan (NETP). Prioritizing 21<sup>st</sup>-century learning, NETP recommended that, "every student and educator has at least one Internet access device and appropriate software and resources for research, communication, multimedia content creation, and collaboration for use in and out of school" (U.S Department of Education, 2010a, p. 61).

Other recent infusions of technology initiatives have concentrated on tests to assess the CCSS. In preparing for the Common Core State Standards, which will start in 2014-2015, states have begun executing significant changes to assessment procedures for measuring academic outcomes. Some schools may be required to make infrastructure changes, prepare for computer-adaptive testing, and for some students, become familiar with new technologies (Cavanagh, 2013; Partnership for Assessment of Readiness for College and Careers [PARCC], 2013; Smarter Balanced, 2013; U.S. Department of Education, 2010b). As elaborated on in a later section in this chapter (Investing in the iPad), numerous schools and districts currently fund large-scale initiatives of a host of unproven technologies, including the iPad.

### **Indicators of Progress**

Improving educational outcomes for all students, not just those with disabilities, is difficult. Less than a decade after EAHCA, the seminal report *A Nation at Risk* outlined challenges America faced in 1983, including low achievement and standardized test scores, poor teacher preparation, and inadequate study skills habits (Gardner, 1983). Classifying the future as "a rising tide of mediocrity," the report expressed concern for a generation of students who

would be “scientifically and technologically illiterate” (Gardner, 1983, p. 12). Since the 1983 report, policy makers have continually searched for levers to raise student outcomes. Yet, three decades later, many of the chief concerns from *A Nation at Risk* still hold true, and are reflected in much of the focus of No Child Left Behind.

In addressing the new progress measures specified in IDEA and NCLB, it is critical to look at key indicators of academic success for students with disabilities. According to the most up-to-date figures, 13% of American students are currently served under federally supported special education programs as of 2009-2010 (U.S. Department of Education, 2012a). Decades after EAHCA, 61% of students with disabilities spend 80% or more of their school day in general education classrooms (U.S. Department of Education, 2012b). In a June 2013 report using adjusted four-year cohort graduation rates, *Education Week* noted that the nation’s graduation rate of 75% reflected an increase for the third straight year, the highest completion rate since 1973 (Education Week, 2013). However for subgroups like students with disabilities, individual states differ in graduation rates upwards of 23%. Thirty states were identified as having graduation rates below 66% for students with disabilities (Civic Enterprises, 2013). Put another way, while nationwide averages of graduation rates are promising, the rates for students with disabilities continue to lag significantly behind those of their peers. Thus, more than 35 years after IDEA, students with disabilities (SWD) continue to live at the margins. One approach to evaluate how the needs of SWD are being addressed is to consider state and school distribution of funds.

### **Resource Allocation**

An analysis of resource allocation by educational leaders may shed light on new education policies. Two of the largest urban school districts in the United States, Los Angeles



and Chicago, have made significant investments in new technology initiatives and are using the iPad to combat the chronically low academic performance in their districts. Specifically, after the 2012-2013 school year, Chicago Public Schools closed over 40 schools and allocated portions of the \$560 million saved for new iPads (Yaccino & Rich, 2013). Similarly, Los Angeles Unified School District committed one billion dollars to providing its 650,000 students iPads for the 2013-2014 school year (Apple, 2013; Blume, 2013a, 2013b, 2013c; Wood, 2013). Thus, only three years old, the iPad has made significant inroads in American classrooms.

### **Investing in the iPad**

Large-scale investment in the iPad as a technology initiative is not unique to Los Angeles or Chicago. For example, the San Diego Unified School District has committed over \$15 million (U-T: SD Unified, 2012; Zouves, 2012), and districts in Tennessee have committed more than \$5 million under the auspices of improving technology in preparation for the CCSS (Broden, 2013; Fagan, 2013). Monies previously earmarked for traditional textbooks are now being used to purchase iPads, and funds allocated to hire staff are being prioritized for iPad purchases (Bernier, 2013; Zouves, 2012). The McAllen, Texas, school district has encouraged teachers to write their own textbooks (Findell, 2013). Finally, the state of Virginia hopes to see a larger return on investment through use of digital books than traditional textbooks (Virginia Department of Education, 2012).

Apple, the maker of the iPad, advertises its product as a transformative classroom tool. With its educational applications, iBooks software, and a wide array of accessibility features for students with disabilities, the iPads holds a great deal of promise for improving student outcomes. The iPad has significant face validity; it is intuitively engaging, displays content in a multitude of formats, and quite simply, makes learning fun. However, without an empirical

research base, educators should approach the device cautiously. No matter how exciting the iPad is, it is not prudent to invest billions of public dollars into a technology not fully researched. If the iPad is to be an effective tool in the American classroom, significant progress must be made in understanding its effectiveness as a classroom intervention (Hu, 2011). Research into understanding the role of the device will aid teachers, schools, and policy makers in providing an appropriate education for students with disabilities.

### **Purpose of this Study**

This study was designed to fill the void in empirical research for iPads in the classroom. Thus, the purpose of the study was to determine the effectiveness of the iPad as an educational tool for increasing outcomes for students with disabilities. Specifically, the iBooks Author software was used to create an interactive iPad iBook, and the effects of the iPad iBook were compared to the traditional textbook. Twenty-two middle school students read three chapters from an iPad iBook and three chapters from a traditional textbook. A variety of measures were taken on or were completed by the students. This chapter and subsequent chapters are an attempt to address the effectiveness of iPad use for SWD in the classroom.

Chapter II reviews the literature related to iPad use for students with disabilities and lists research questions. Chapter III outlines the methodology for the study design, a repeated measures intervention design that employed quantitative and qualitative measures. Chapter IV presents findings related to the effects of an iPad iBook, including measures of reading comprehension, electrodermal activity (EDA), cognitive load, satisfaction, and two semi-structured interviews. Finally, Chapter V discusses relationships to previous research, limitations, and implications for future research.

## CHAPTER II

### LITERATURE REVIEW

Adolescents with specific learning disabilities (SLD) often have difficulties with reading (Catts, Adlof, & Weismer, 2006; Deshler & Schumaker, 2006; Edmonds et al., 2009; Swanson, 1999; Vaughn et al., 2008). In fact, 80% or more of students with a SLD demonstrate reading difficulties (Cortiella, 2011). These include learner-centered difficulties such as impaired executive functioning skills that adversely affect attending, retaining, and expressing important information from a text (Anderson, 2002; Berkeley, Scruggs, & Mastropieri, 2010; Fagella-Luby & Deshler, 2008; Roberts et al., 2008). Instructional and environment-centered difficulties further complicate learning for students with disabilities (SWD), given that curricula and texts become more complex and challenging as students advance into the junior and senior high level (Bulgren, Deshler, & Lenz, 2007; Bulgren, Marquis, Lenz, Schumaker, & Deshler, 2009).

It is important, therefore, to take these factors into consideration when designing interventions for adolescents with SLD. One intervention that is frequently used in special education, the computer, achieved increased popularity when the Apple iPad was introduced, prompting school districts to make large investments in the iPad as a classroom intervention (Apple, 2013; Blume, 2013b; Yaccino & Rich, 2013).

In this chapter, to better understand how the iPad can serve as a potentially valuable tool for SWDs, three literature bases will be reviewed: (a) interventions and teaching practices for students with SLD; (b) new literacies environments and technologies, including online and digital, as well as the Apple iPad and iBooks software, and (c) elements of good design through the lenses of Universal Design for Learning (UDL) and textbook instructional design. Finally, a

logic model will be presented that displays how and what outcomes may be expected through use of the iPad iBook in the classroom.

### **Interventions for Students With Specific Learning Disabilities (SLD)**

As students progress into middle and high school, reading instruction is frequently no longer provided or is reduced to cursory instruction in how to read content-area material (Carnahan & Williamson, 2013; RAND Reading Study Group, 2002). This is often referred to as the transition from “learning to read” to “reading to learn.” Research on adolescent literacy has suggested that while “reading to learn” instruction for older students is similar to such instruction for younger students, it is nevertheless different (Edmonds et al., 2009; RAND Reading Study Group, 2002; Snyder, 2010). Thus, instructional designers are challenged with developing effective teaching practices for struggling learners that accomplish both goals of reading to learn and learning to read.

The following section elaborates on the research synthesis conducted by Fagella-Luby and Deshler (2008) and highlights recent and seminal reports, analyses, and articles relevant to teaching adolescents with SLD interventions how to comprehend complex texts contained in the Fagella-Luby and Deshler synthesis. Particular attention is given to instructional practices, such as classroom activities or teaching components that aid in improving reading outcomes.

**Swanson (1999) meta-analysis.** Swanson conducted a seminal meta-analysis of 92 intervention studies that used an experimental design (and in the same year, a follow-up article) focusing on word recognition and reading comprehension instructional practices for adolescents with LD (1999a, 1999b). Dependent measures included word recognition and reading comprehension. This synthesis serves as a cornerstone in understanding the components necessary for developing effective interventions and instructional practices for students with

SLD, and will be outlined below as a framework for understanding quality instructional reading comprehension practices.

First, he coded 45 instructional activities, organizing them into 20 instructional components thought to uniquely influence learning. Specifically, they included

1. Sequencing
2. Drill / repetition and practice / review
3. Anticipatory or preparation responses
4. Structured verbal teacher-student interaction
5. Individualization and small group
6. Novelty
7. Strategy modeling and attribution training
8. Probing / reinforcement
9. Non-teacher related instruction
10. Segmentation
11. Advance organizers
12. Directed response / questioning
13. One-to-one instruction
14. Difficulty or processing demands of task
15. Technology
16. Elaboration
17. Modeling of steps by teacher
18. Group instruction
19. Supplement to teacher involvement (but not by peers)
20. Strategy cues, (Swanson, 1999a, pp. 508-509)

The 20 instructional components were further coded to reflect the specific teaching methodology used; namely. direct instruction (DI) or strategy instruction (SI). Studies using bottom-up instruction that focused on isolated reading skills were coded as DI. DI involved four or more of the following activities:

1. Breaking down a task into steps
2. Administering probes
3. Administering feedback repeatedly
4. Providing a pictorial or diagram presentation
5. Allowing for independent practice and individually paced instruction
6. Breaking the instruction down into simpler phrases
7. Instructing in a small group
8. Teacher modeling a skill)
9. Providing set materials at a rapid pace

10. Providing individual child instruction
11. Teacher asking questions
12. Teacher presenting the novel materials, (Swanson, 1999a, pp. 507-508)

Studies using top-down instruction that focused on processes or global skills were coded as SI. SI involved three or more of the following activities:

1. Elaborate explanations
2. Modeling from teachers
3. Reminders to use specific strategies or procedures
4. Step-by-step prompts or multiprocess instructions
5. Verbal-interactive dialogue
6. Process questions asked by the teacher
7. Assistance provided by the teacher only as necessary, (Swanson, 1999a, pp. 508)

Using the DI and SI components, Swanson determined the effect sizes of four instructional models: DI alone, SI alone, DI+SI, and Non-SI+Non-DI, which yielded the following results. First, when compared to other models, effect sizes were highest when instruction included components of both DI and SI. Effect sizes for the combined model ( $M = 1.15$ ) yielded estimates that exceeded Cohen's .80 criterion for a significant finding (Swanson, 1999b). Additionally, regardless of the model of instruction used, the following 6 of the 20 core instructional components were found to be effective components of an intervention: (a) directed response/questioning, (b) controlled difficulty of processing demands of task, (c) elaboration, (d) teacher modeling of steps, (e) group instruction, and (f) strategy cues. These components played a greater role in affecting and predicting effect sizes for reading comprehension than others.

Second, regardless of instructional model, small-group interactive instruction and strategy cuing contributed significantly to effect size variance (Swanson, 1999b). Further, a related meta-analysis also conducted by Swanson (Swanson & Hoskyn, 2001) indicated that advance organizers and explicit practice as contributing unique variance to comprehension outcomes. Together, these findings suggest that it was not a bottom-up or top-down approach in

isolation that predicted the best academic outcomes for students. Instead, a combined DI+SI model appeared to be the most robust for reading comprehension outcomes (1999a, 1999b).

**Edmonds, et al. (2009) meta-analysis.** Edmonds, et. al. (2009) conducted a synthesis of 29 studies between 1994 and 2004 that used interventions for adolescents in grades 6-12 with reading difficulties. Studies were required to measure aspects of reading (such as reading comprehension) to be included in the synthesis. Good readers, unlike poor readers, the authors noted, are more likely to note structure and organization of text, self-monitor during reading, use summaries, and make inferences and use visualizations (Edmonds et al., 2009). Furthermore, good comprehension instruction at the elementary and secondary level addresses these components (Curtis & Longo, 1999; Fagella-Luby & Deshler, 2008; Gajria, Jitendra, Sood, & Sacks, 2007). To this end, the meta-analysis highlighted two important findings for struggling readers.

First, reading comprehension outcomes for struggling readers can be improved. This finding reinforces Swanson's findings, and suggests that older students (and in this synthesis, specifically SWD) can be taught to effectively comprehend complex texts and make significant reading gains when explicit and strategic instruction is used (Carnahan & Williamson, 2013). "Explicit instruction," noted Edmonds and colleagues, "yields strong effects for comprehension for students with learning difficulties and disabilities" (2009, p. 3). Strategy instruction here included modeling, think-alouds, self-questioning and reflection, and actively engaging students in understanding and processing text.

Second, Edmonds et al. (2009) noted that although students are required to read more informational or expository text as they progress from elementary to secondary school, effect sizes for comprehension interventions were lower for expository texts than for narrative texts.

They recommended that, like Swanson’s strategy instruction activities, interventions using graphic organizers or drawing attention to text structures be considered to address the less effective interventions for expository texts.

**Gersten, Fuchs, Williams, and Baker (2001) review.** Gersten et al. (2001) reviewed the literature on effective instructional methods for reading comprehension for students with SLD. Inclusion in the review required an experimental or quasi-experimental design using an intervention that quantitatively measured reading comprehension as a dependent variable. Similar to Edmonds et al. (2009), the authors noted that most reading and learning beyond elementary school requires a significant amount of expository text, as does everyday adult functioning. When compared to their narrative counterparts, expository texts (a) do not always involve prompts or identifiers to more easily follow the content, (b) may be more abstract, and (c) are more complicated (Gersten et al., 2001).

Given that the increase in expository texts adolescents face in secondary school, learning ways to comprehend—and do so effectively and efficiently—is paramount for struggling adolescent readers to improve their academic outcomes. Specifically, for purposes of this review, the authors noted that students with disabilities are less likely to overtly use strategies for comprehending such texts and, in turn, addressed techniques for improving expository text comprehension, including making readers reflect on the content, what they have learned, and how it is integrated into the larger picture (Gersten et al., 2001).

Gersten et al. (2001) noted three important conclusions. First, it appeared that deliberate and systematic teaching of strategies positively impacts student comprehension. Second, strategy instruction should include the following components to aid in comprehension of complex expository texts: describing, modeling, monitoring, practicing, and providing feedback. Related,



a recent meta-analysis has backed usage of these components too, specifically through use of strategies and social studies expository texts (mean ES = 1.02) (Swanson et al., 2012). Finally, considering that expository texts vary in text structures, purposes, and organization, the authors recommended using multiple comprehension strategies to best address the wide array of text types.

**Mastropieri, Scruggs, and Graetz (2003) review.** Some have called the complexity of content-area textbooks a lack of “considerateness” (Armbruster & Anderson, 1998), suggesting that secondary-level textbooks lack structures that are easy to follow (Mastropieri, Scruggs, & Graetz, 2003). The vast breadth covered in content-area texts, argued Mastropieri, Scruggs, and Graetz, is often dense and overwhelming, and provide too many facts, vocabulary, and details without sufficient explanation. Accordingly, the authors identified seven best practices for teaching reading comprehension for SWD at the secondary level. The review of several major syntheses did not include analysis of dependent variables. A summary of the practices follows.

First, interventions should contain components of cognitive strategy and direct instruction in guided and independent practice. Second, effective comprehension strategies for younger students with SLD are also effective for older students with SLD (Catts, Adolf, & Wesimer, 2006). Third, adequate time must be provided for strategy instruction, including time for practice and repetition. Fourth, “deliberate, intensive interaction with the text” aids in student engagement and sense-making (p. 114). Fifth, peer tutoring strategies improve reading comprehension. Sixth, multiple means of representation can result in better learning outcomes. Finally, the dosage, or intensity, of strategy instruction is as important as the strategy itself (Mastropieri, Scruggs, & Graetz, 2003).

In summary, the authors recommended implementation of high-quality reading comprehension instruction for students with SLD to address the so-called inconsiderateness of textbooks. They also encouraged future researchers to include supplemental materials addressing considerateness to foster higher reading comprehension outcomes.

**Vaughn, Gersten, and Chard (2000) review.** Vaughn et al. (2000) presented a summary of research syntheses from which the authors identified 11 Principles of Instruction for Students with Learning Disabilities. The authors did not analyze the research using dependent measures. The 11 principles are summarized below (p. 110):

1. Effective instructional approaches consisting of visible and explicit components
2. Instructional practices that:
  - a. Assist students in developing a plan of action to guide their learning
  - b. Are interactive and associated with improving reading outcomes
  - c. Include interactive dialogue between students and teachers
3. Variables critical to influencing learning outcomes include:
  - a. motivation to learn
  - b. Task difficulty
  - c. Task persistence
4. Integrate both bottom-up and top-down instruction
5. Instruction that benefits all learners include:
  - a. Reciprocal teaching
  - b. Classwide peer tutoring and peer-assisted learning strategies
  - c. Content enhancement

According to Vaughn et al. (2000), when following the above principles, learning is enhanced for all students, not just those with SLD. The authors concluded their synthesis by noting that the design of instruction includes both bottom-up and top-down strategies (Swanson, 1999a, 1999b; Swanson & Hoskyn, 2001).

**Berkeley, Scruggs, and Mastropieri (2010) meta-analysis.** In one of the most recent meta-analyses, Berkeley, Scruggs, and Mastropieri (2010) synthesized 40 studies from 1995-2006 that focused on outcomes for students with SLD. Unlike other studies mentioned in this

review, this meta-analysis investigated (among others) the treatment factors associated with high-quality comprehension instruction for SLD. Reading interventions were grouped into four dependent measure categories: (a) questioning/strategy instruction, (b) text structure, (c) fundamental reading skills, and (d) other. A number of results are relevant for this review.

First, significant outcome differences were found among treatment delivery agents ( $p < .05$ ). Specifically, when using interventions consisting of criterion-referenced measures, the delivery agent was found to have higher effect sizes for researchers (mean ES = 0.83) than for teachers (mean ES = 0.56), a finding similar to Solis and colleagues (2012), who noted large effects for researcher-developed measures of comprehension. This may be due to researchers being more familiar with an intervention and how to properly assess reliability and intensity.

Second, treatment effects for criterion-referenced measures were statistically significant ( $p < 0.05$ ) across grade levels. Treatment effects were larger for middle school (mean ES = 0.80) than for elementary school (mean ES = 0.52). Finally, treatment effects for criterion-referenced measures were higher (mean ES = 0.70) than for norm-referenced measures (mean ES = .52).

These findings suggest that interventions for reading comprehension were generally more effective when implemented by researchers using criterion-referenced assessments at the middle school level. Berkeley et al.'s (2010) findings agree with Swanson's work in that the mean effect sizes found by Berkeley et al. ( $M = .65$ ) were similar to Swanson's (1999) ( $M = .72$ ).

**Scammacca, Roberts, Vaughn, and Stuebing (2013) meta-analysis.** Finally, in the most recent large-scale review of reading interventions for struggling adolescent readers, Scammacca, Roberts, Vaughn, and Stuebing (2013) synthesized more than three decades' worth of research for struggling readers in grades 4-12. Studies were included that met criteria of an experimental or quasi-experimental design that measured dependent variables associated with

reading constructs. Three findings from their synthesis further contribute to the field of reading comprehension interventions for students with SLD.

First, in terms of the largest effect size, vocabulary interventions produced the largest (mean ES = 1.58), followed by reading comprehension (mean ES = .74), word study (mean ES = .33), fluency (mean ES = .30), and multiple components (mean ES = .20). All differences were significant ( $p < 0.05$ ), suggesting that vocabulary interventions had a significantly larger mean effect size on reading comprehension than other intervention types.

Second, in terms of the number of implementation hours of an intervention, Scammacca et al. (2013) found that shorter interventions yielded higher effect sizes than longer interventions. Number of hours was investigated at the categorical level (i.e., 0-5; 6-15; 16-25; 26+), and significant differences were found using pairwise comparisons across all groups ( $p < 0.05$ ). The authors theorized that the reason for higher effects in the 0-5 (mean ES = 1.00) and 6-15 (mean ES = 0.66) groups compared to the 16-25 (mean ES = 0.27) and 26+ (mean ES = 0.18) groups was due to coding the variables at the categorical and not continuous level.

Finally, Scammacca et al.'s study (2013) strengthened Berkeley et al.'s (2010) findings favoring larger effect sizes when a researcher implemented an intervention. Thus, effect sizes for researcher-implemented interventions were higher (mean ES = 0.68) than for teacher-implemented interventions (mean ES = 0.35), and significant at the  $p < 0.05$  level. The authors concluded by recommending that future researchers address "the current state of business-as-usual interventions for struggling readers," and include ways to examine and study current practices in classrooms (p. 19).

**Summary.** Together, the above reviews, syntheses, and meta-analyses primarily focused on dependent variables associated with components of reading, most commonly reading

comprehension. This research also outlined effective instructional practices for teachers. Three important recommendations may be derived from the above review. First, the divide between learning to read and reading to learn is important and must be addressed. A lack of secondary reading instruction widens the performance gap noted by Deshler and Hock (2007), and highlights that instruction must address both how to read and how to retrieve valuable information and more deeply understand content (Biancarosa & Snow, 2004; Carnahan & Williamson, 2013; Deshler & Hock, 2007; Edmonds et al., 2009; RAND Reading Study Group, 2002; Snyder, 2010).

Second, research recommends the use of a combined explicit and strategy instruction model. Many peer-reviewed reports and articles have backed up the claim that explicit reading instruction benefits adolescents with SLD (Biancarosa & Snow, 2004, Bulgren, Schumaker, Deshler, Lenz & Marquis, 2002; Edmonds et al., 2009; Swanson & Deshler, 2003; Swanson & Hoskyn, 2001; Vaughn, Gersten, & Chard, 2000). The process of describing, modeling, monitoring, practicing, and providing feedback is critical to making learning systematic and meaningful. Furthermore, strategy instruction that includes activities and content enhancements such as advance organizers, cues, text clues, and think-alouds engages students in reading, processing, and understanding complex expository texts (Boudah, Schumaker, & Deshler, 1997; Bulgren, Deshler & Lenz, 2007; Conley, 2008; Deshler et al., 2001; Roberts, Torgesen, Boardman, & Scammacca, 2008; Scruggs, Mastropieri, Berkeley, & Graetz, 2010).

Finally, it appears that quality reading comprehension instruction for students with SLD, also benefits students without disabilities (Mastropieri, Scruggs, & Graetz, 2003; Scammacca, Roberts, Vaughn, & Stuebing, 2013; Vaughn, Gersten, & Chard, 2000). When providing differentiated supports and services for all learners, then, it appears that the development of

interventions for struggling learners is an efficient and effective method for improving academic outcomes for all students.

### **New Literacies Environments and Technologies**

Through use of the latest classroom technologies –such as word processing and presentation software, audio and video editing tools, and always-on Internet access—new learning experiences are now accessible to all learners. It is important to differentiate how these technologies uniquely impact classroom instruction and learning when compared to traditional, print-based learning. Some have coined these practices as “emerging technologies” that explore and progress undiscovered territories (Joy, 2000), whereas others consider them wholly new literacies. Identifying emerging technologies in the classroom as “new literacies,” Leu and colleagues provide a useful lens from which to view how online and digital learning environments impact academic outcomes (Leu, Kinzer, Coiro, & Cammack, 2004).

The following section describes research using this lens and highlights (a) new literacies theory, (b) emerging or new literacy technologies within the field of special education, and (c) the Apple iPad hardware and iBooks Author software. Particular attention is given to potential dependent measures that may be useful in studying and understanding new online and digital forms of learning.

**New literacies theory.** “New literacies” theory refers to identifying changes in social forces and technologies that utilize new forms of information and community technologies (Leu, Kinzer, Coiro, & Cammack, 2004; Leu et al., 2011). In a global age, new technologies generate new literacies that become integral parts of human life. Leu and colleagues (2004) hypothesized the effects of new literacies and their effects on reading comprehension. New literacies involve new skills, strategies, and dispositions used to learn and comprehend the Internet, blogs, word

processors, video games, email, and text and instant messaging to facilitate learning (Leu et al., 2004). For students, this emerging technology—also called online reading comprehension—may pose a different set of demands than traditional, offline reading comprehension. “It remains to be seen,” Leu and colleagues commented, “if our standards, curriculum, and assessments, and the instructional practices that are closely related to each, can keep up with the continuous changes taking place in literacy” (2011, p. 11). When examining educational policies and reform efforts, then, it is important to consider and carefully leverage the literacies, skills, and strategies most often used by students.

Leu et al.’s New Literacies of Online Reading Comprehension theory (2011) outlines five elements of new online and traditional offline reading comprehension skills, as summarized below:

1. Reading Online to Identify Important Questions, such as to solve problems or answer questions
2. Reading Online to Locate Information, such as using strategies to search and find important information
3. Reading Online to Critically Evaluate Information, such as to determine levels of accuracy, reliability, and bias
4. Reading Online to Synthesize Online Information, such as to collect multiple sources and media formats
5. Reading Online to Communicate Online Information, such as to collaborate and share. (p. 7)

Many of the elements of new literacies theory are present in traditional, offline literacies. Through the lens of new literacies theory, though, Leu and colleagues (2011) noted that teachers’ roles shift. Specifically, teachers are challenged to thoughtfully guide student learning within information-rich environments like the Internet. Given the five elements listed above, teachers’ understanding and use of new communication tools, means of presenting and teaching content, and supporting student learning changes.

***Related literacy descriptions.*** Mills, in her review of empirical work involving new literacies, called this shift a “digital turn” towards new environments and social contexts (Mills, 2010, p. 246). Using cross-comparisons of ethnographies in digital environments, she identified practices that include words in combination of audio, video, spatial and gestural modes as multimodal texts, which fits within the possibilities of an iPad iBook. Similarly, the New London Group named this “multiliteracies” in an attempt to unify and broaden literacy pedagogy when navigating the fields of linguistics and cultural demands (Cazden et al., 1996), whereas Jewitt noted “multimodalities” and “multiliteracies” as terms that refer to the ways in which content is both presented how it is to be learned (2008, p. 241). Together, the theories of multimodal and multiliteracies represent the unique act of “doing literacy,” which has become an increasingly broader definition than when simply considering print-based texts (Jewitt, p. 248).

A difficulty of conventional print-based texts, argued Mills, is that they do not consider the “unintended cognitive and social collateral achievements of digital practices” and “lack life validity since they do not reflect the authentic digital literacy practices in social contexts beyond schools” (p. 262). Furthermore, while it is necessary that literacy include the acts of reading and writing, it is not sufficient without the sense- and meaning-making that comes from the digital communications new literacies offers through use of the Internet, watching videos, listening to audio clips, or connecting to students’ personal experiences. Particularly, Mills noted that stronger connections have been found between learning and motivation when literacies include aspects of individual choice and high engagement, such as through gaming, online communication, digital presentations of poetry, and music (p. 254), however few studies were found that measured motivation as a dependent variable when considering new literacies. The



author concluded with recommendations for qualitative and quantitative studies that included assessments of new literacies' design components in educational settings.

What is needed, both Leu and colleagues and Mills proposed, is research that identifies the skills and strategies necessary to access and use new literacies. For instance, when comparing a textbook, or “touchstone” of education (p. 11) to reading a text on the Internet or in a PowerPoint presentation, different aspects of comprehension are required (Leu et al., 2011). Research that addresses the interactions of new online and traditional offline learning can further enhance our understanding of these learning environments. The following section outlines studies that address technology use for students with disabilities, which includes aspects of new literacies.

**Assistive technology.** Within the Individuals with Disabilities Education Act, assistive technology is defined “as any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities” (IDEA, 2004). Assistive technologies, or AT, may refer to physical technologies like a wheelchair or a hearing aid, as well as computer assistive software and augmentative and alternative communication devices. Particularly, computer hardware and software allows students with specific learning disabilities, like dyslexia or ADHD, to access literacies. Zhao noted the use of speech technology as potentially supportive for SWD (2005). Speech recognition, or speech-to-text, allows students to dictate to a computer, essentially controlling and commanding its functions. When used in conjunction with word processing software, students are able to write papers, correct grammar and punctuation, and perform everyday functions not dissimilar from all computer users. Similarly, speech synthesis, or text-to-speech, allows for SWD to access content via a human-

like voice output. Zhao noted that this method is an effective use of technology for students with specific learning disabilities, reducing the frustration of inaccurate decoding and allowing for comprehension of more complex texts (Zhao, p. 37; MacArthur et al., 2001). Okolo and Bouck found in their review of empirical AT research from 2000-2006 that nearly one-third of AT studies included students with high-incidence disabilities, which included SLD (2007). However, whereas 32% of the 122 studies that met criteria focused on literacy-related dependent measure outcomes, only 10% focused on social/emotional aspects of assistive technology, a gap in the literature highlighted earlier in this section by Mills. Finally, it is important to note that in a 2013 study surveying pre-service teachers on their AT-related preparation, participants felt a lack of general assistive technology knowledge. In surveying 77 pre-service teachers, Poel, Wood, and Schmidt (2013) found low pre-service teacher knowledge in how to work with AT professionals and specifics related to the IDEA law concerning AT. The authors recommended that future research address how to best infuse AT into classrooms and make it accessible for teachers.

**Computer-assisted instruction.** Computer-assisted instruction (CAI) refers to the use of computers in instructional or educational programs. Common uses in the classroom, as outlined by Bayraktar (2002) in a seminal meta-analysis on CAI, may include: drills & practices, tutorials, or simulations. Examples of CAI use may include vocabulary practice in science, technology, engineering, or mathematics (STEM) fields, and in the language arts may include activities in phonetic spelling, writing, phonological awareness, letter-sound correspondences, and decoding (Torgesen et al., 2010). Furthermore, CAI may include games and game-like activities that guide students through a series of shaping or scaffolding activities leading to the desired outcome. Two recent meta-analyses, by Bayraktar (2002) and Blok et al. (2002) highlight findings for this type of new literacy instructional environment.

Bayraktar (2002) identified 42 studies that included participants at the secondary and post-secondary level investigating CAI for science-based learning. No identification of students with disabilities was provided. Student achievement served as the dependent variable. From a total of 108 effect sizes, an overall effect size mean of 0.273 was found, which represented a small positive effect. However, Bayraktar (2002) found that simulation activities had the largest effect size ( $d = 0.391$ ), followed by tutorials ( $d = 0.369$ ). However, for drill and practice activities, a negative effect size was found ( $d = -.107$ ). The small overall effect size suggested that CAI may not be a highly-effective intervention for secondary and post-secondary students studying STEM fields, however when used as a supplemental activity and not a substitute for instruction, effect sizes were higher ( $d = 0.288$ ;  $d = 0.178$ ).

Blok et al., (2002) conducted a meta-analysis of computer-assisted instruction for beginning reading activities across 42 studies for elementary and middle school students, including those identified as having a disability. Dependent variables included seven subsets of reading: (1) phonological skills, (2) letter identification, (3) word identification accuracy, (4) word identification speed, (5) oral text reading accuracy, (6) oral text reading speed, and (7) other. A combined effect size across all CAI reading subsets was found to be 0.254, a finding very similar to Bayraktar's. CAI programs appeared to have only a small effect size on students' beginning reading measures, a finding strengthened by MacArthur et al.'s (2001) review of CAI and word identification studies.

In summary, computer-assisted instruction is strengthened when used as a supplement to teacher instruction rather than as a substitute, and may be best utilized when closely monitored and guided by the classroom teacher, a finding strengthened by others (Torgesen et al., 2010). In

summary, computer-assisted instruction appears to have a small, positive effect on achievement outcomes.

**Apple's iPad and iBooks Author software.** The Apple iPad was released in April 2010, and the developers immediately “invite[d] us to imagine what is possible” (Culture of Code, 2010). The device provided a full-fledged personal computing tablet with an accessible user interface, web browsing, word processing, multimedia creation and consumption, lengthy battery life, durability, and portability for a price significantly less than that of a similarly featured laptop. Downloadable programs from the Apple App Store allow teachers and students to morph the tablet into a powerful classroom tool, catering to specific and individual needs. As cited in Mary Meeker and Liang Wu's 2013 *Internet Trends: D11 Conference* presentation, demand for computing devices has never been higher than during the first quarter of 2013. Similarly, in 2013, the demand and interest level for tablet computers in the classroom has been higher than ever.

The iPad iBooks software, iBooks and iBooks Author, offers an innovative way for students to explore and learn about the world; it is interactive, potentially sensitive to learner accessibility with features like text-to-speech and highlighting of critical information, and may be useful in advancing the executive functioning performance of students with disabilities (Barkley, 1997; Meltzer & Krishnan, 2007). Furthermore, the online learning environment of an iPad iBook may be enhanced through features mentioned in Mayer's work, such as video and audio, interactivity, or note taking.

However, considering that the iPad has been commercially available for only 40 months and the iBooks Author software for only 20 months, intervention research using the device for students with specific learning disabilities is limited. In fact, no peer-reviewed studies with the

iPad iBook as an intervention for adolescents with disabilities were identified for this review. Instead, the following highlights several recent and current initiatives using the iPad, some of which use the iBooks software.

***Gertner's study.*** Gertner (2011) investigated the effects of textbook and e-text for 69 college students using comprehension and transfer learning measures. After randomly being assigned to a traditional text or e-text group, students read a chapter from a psychology textbook or iPad. Dependent measures consisted of reading comprehension and transfer learning scores. Results from an ANOVA indicated no significant differences in comprehension scores. However, significant differences between groups were found in transfer learning for the iPad treatment ( $p < .01$ ). An effect size of 0.85 was found. These differences in transfer learning produced small differences in learned material, namely  $M = 3.5$  for the traditional textbook and  $M = 5.0$  for the iPad. The author concluded that similar comprehension scores indicated the iPad was at least comparable to a traditional textbook for reading comprehension. This study suffers from a small sample size, a non-K-12 population, and measures that were not validated, resulting in an important but incomplete initial analysis of the iPad and measuring academic outcomes.

***Houghton Mifflin Harcourt's pilot study.*** A large textbook publisher, Houghton Mifflin Harcourt (HMHCO), conducted a pilot study using an iPad textbook (HMHCO, 2013). Two middle school classrooms were randomly assigned one of two mathematics books: a traditional textbook or an iPad textbook. For the duration of the school year, students used that particular book format. Dependent variables included measures of mathematics test scores. Results indicated performance increased by 78% for students using the iPad format compared to 59% for traditional textbook users.

Unfortunately, the study suffered from a lack of transparency and rigorous research methodology (e.g., no demographic data are presented, statistical analysis are not described, no details are presented on dosage, intensity, or instructional methods; The Policy Brief, 01/27, 2013). Shortly after the release of this study, the publisher removed it from circulation. For these reasons, this study is of limited value.

***State of Virginia's pilot study.*** The state of Virginia conducted a pilot study using iPad as classroom textbooks (Beyond Textbooks, 2011, 2012). Two cohorts of students participated: one AP biology cohort of 40 students, and one AP biology cohort of 34 students. Student performance data on final exam, final course, and biology SOL (Standard of Learning) scores served as dependent variables. Mean scores for the treatment groups in Year 1 were higher than those of the control group on all three measures. Mean scores for the treatment groups in Year 2 were mixed; students using the iPad had higher scores on the final exam but lower scores in the course. No biology SOL scores were collected. Qualitative analysis included interviews and questionnaires.

Results indicated that students liked the ability of the iPad to support individualized learning and instruction. Interactivity features and widgets of the iPad were cited as improving engagement. Many students preferred the iPad for other classes; however, some desired to continue using traditional textbooks. Also, students were more likely to collaborate when using the iPad iBook than the traditional textbook. Teachers reported enjoying iPad's ease of use. Teachers also noted increased student independence and engagement when using the iPad format.

Limitations of this study include a lack of statistical analysis and adequate methodology. Mean differences within and between cohorts were found, but no statistical analysis, such as an

independent samples *t*-test, was conducted. Furthermore, the methods of the study were not fully explored, making it difficult to replicate.

**Summary.** iPads are the predominant piece of technology being purchased for classrooms and schools today (Meeker & Wu, 2013). As such, many students with and without disabilities are using the iPad as a textbook and for other learning purposes. However, no peer-reviewed studies using the iPad iBook as an intervention for SWDs were identified for this review. It is obvious that the iPad has generated strong interest among educators, and it appears to lead to high student engagement. What is less obvious is the degree to which it is an effective classroom tool. The few studies available demonstrated high interest and engagement for the iPad, but the very low-quality empirical research practices make these findings inconclusive. Nevertheless, it is possible to measure student engagement and affective reaction to such a device, including measuring students' socio-emotional response to the iPad using physiological data.

**Electrodermal Activity (EDA).** Electrodermal activity (EDA) has been used in psychology, psychiatry, and psychophysiology research to investigate factors of attention, executive functioning, and emotion across a wide range of clinical and real-world settings. Its wide application stems from ease of data collection and ability to quantify psychological and cognitive states and processes (Dawson, Schell, & Filion, 2007; Fowles, 1980; Malmivuo & Plonsey, 1995). No studies up to this point of the literature review used classroom-based interventions for students with disabilities measuring the physiological aspects of learning. EDA may serve as an important measure for researchers to consider when conducting future new literacies studies.

EDA measures skin conductance, a measure of physiological arousal. Arousal responses may be due to changing emotive state, attention, or a change in cognitive workload. EDA

measures have important interpretations for the autonomic nervous system, of which the sympathetic nervous system is commonly referred to as the “fight-or-flight” system of the human body. For example, it is this system that is responsible for regulating body temperature, commonly through the output sweat via skin glands (Malmivuo, & Plonsey, 1995). Carl Jung, the famous psychiatrist and scientist, was one of the first to consider galvanic skin responses as a vehicle for measuring biofeedback and emotional arousals (Jung, 1907). Jung found EDA to be an objective measure of the “hidden aspects of hidden complexes” (Dawson, Schell, & Filion, 2007, p. 160).

Arousal measures of the human body are made possible with the Q-Sensor through sweat, body temperature, and heart rate (Boucsein et al., 2012). These metrics make EDA measurement possible. Furthermore, these “responses in the skin serve as emotional expressions and social signals that help mould interindividual interactions” (Critchley, 2002, p. 132). It is these “subjective feelings of autonomic bodily changes [that allow for] important influences on individual emotional experiences” (Critchley, 2002, p. 133). Measurement of the body’s response to textbook stimuli through EDA levels measures factors that are seldom considered but may enhance our understanding of the learning process. In totality, these measures can support the triangulation and interpretation of multiple data sources. As such, EDA provides an objective measure of emotional behavior and responses. This study employed subjective self-reported measures of cognitive workload and satisfaction, and semi-structured interviews to assist in understanding student perception of the iPad iBook as an intervention,

Studies using EDA as a measurement commonly employ a traditional experimental design; an antecedent is presented, a behavior is demonstrated, and a consequential response is immediately measured. These types of immediate skin conductance responses (SCRs) are



referred to in the literature base as phasic (Benedek & Kaernbach, 2010; Boucsein et al., 2012; Braithwaite, Watson, Jones, & Rowe, 2013; Critchley, 2002; Malmivuo & Plonsey, 1995).

*Phasic* events typically occur for periods of 10-15 seconds as a response to environmental stimuli. They are often measured using frequency counts of peaks divided by a length of time, and may be used as a measure of engagement or activation.

Conversely, slower shifts of skin conductance levels (SCLs) are called *tonic* measures, lasting for several minutes. EDA changes are slower to occur but can also be measured when compared to a rest, baseline, or mean or average level. Because EDA is sensitive to slower shifts in SCLs as well as more rapid shifts via skin conductance responses SCRs when humans interact with a stimulus, it is normal to demonstrate an emotional, anticipatory response in EDA levels (Benedek, & Kaernbach, 2010; Braithwaite et al., 2013; Critchley, 2002; Dawson, Schell, & Filion, 2007; Picard, 2011).

Due in large part to advances in more sensitive measurement technologies, signal thresholds for evaluating EDA levels have shifted from the traditional 0.05  $\mu\text{S}$  (microseconds) to levels of 0.04  $\mu\text{S}$ , 0.03  $\mu\text{S}$ , and 0.01  $\mu\text{S}$ . Significant changes in EDA levels—specifically those identified in this study as important responses to stimuli—are commonly identified as changes greater or less than the 0.1 level (Braithwaite et al., 2013; Malmivuo & Plonsey, 1995). Finally, the Q-Sensor measures physiological data every tenth of a second, resulting in a continuous acquisition rate of data during the intervention.

Interpretation of electrodermal activity in and of itself can be difficult. EDA can be used to index processes like activation and attention, and it has been closely linked to emotional and cognitive processing (Braithwaite et al., 2013; Dawson, Schell, & Filion, 2007; Fowles, 1980). While the Q-Sensor sufficiently detects changes in arousal levels, it does not distinguish between

positive or negative affects (Davies & Gavin, 2007; Picard & Daily, 2008). Particularly, a “low” EDA level may suggest a relaxed state or a lack of activation that may be calm and peaceful, or disengaged and bored (Affectiva, 2013). Conversely, a “high” EDA level may suggest being more responsive or attentive to the environment. However, this, in turn, could mean a more stressful situation, or a more exciting situation.

Interpreting EDA levels in and of itself is not within the scope of this study. It is appropriate, however, to discuss participants’ EDA levels in conjunction with the other measures used. For purposes of this summary, empirical peer-reviewed studies from the last two decades containing the keywords “disability,” “electrodermal activity,” and forms of “technology” and “intervention” were identified. Although some have hypothesized about such research (Munson & Pasqual, 2012), no studies were identified that included electrodermal activity measures of students with disabilities when using an iPad iBook. Even fewer studies were found that investigated the differences in EDA as a dependent variable used to understand a learning environment or intervention. Most studies using this technology have investigated qualitative and quantitative differences in student characteristics, such as students with ADHD (attention deficit hyperactivity disorder) versus non-ADHD. Furthermore, studies mentioned in previous sections within this chapter have noted connections between technology-based interventions and benefits associated with student motivation, (Mills, 2010; State of Virginia, 2011, 2012), however Given the lack of research directly relating to this study, the below section instead describes relevant studies within the last two decades using electrodermal activity for students with disabilities.

***Studies measuring electrodermal activity for SWDs.*** A significant portion of the research findings for adolescents with disabilities and electrodermal activity measures involved students diagnosed ADHD (Mangina, Beuzeron-Mangina, & Grizenko, 2000; Mangina & Beuzeron-

Mangina, 2009; Miller, Nielsen, & Schoen, 2012; O’Connell, Bellgrove, Dockree, & Robertson, 2004; Shibagaki, Yamanaka, & Furuya, 1993). Findings using EDA levels suggest that students with ADHD exhibit higher error rates in tasks, make poorer decisions, and demonstrate deficits in sustained attention (Crone & van der Molen, 2007; Dykman, Ackerman, Holcomb, & Bourdeau, 1983; Miller, Nielsen, & Schoen, 2012; O’Connell et al., 2004). Physiological data from the O’Connell et al. (2004) study suggested that students with ADHD had a decreasing emotional response to task errors and were less likely to correct their errors. Shibagaki and colleagues (1993) studied EDA level responses during passive and active listening tasks for 18 students with ADHD. Participants with ADHD were found to exhibit lower EDA levels than their non-ADHD peers, suggesting short attention spans. Other studies have strengthened this claim, finding that students with ADHD exhibit lower EDA levels during cognitive workload than their nondisabled peers (Mangina et al., 2000).

Working memory processes, it seems, lead to the highest EDA levels in students without disabilities, followed by those with ADHD-only and those with SLD-only; the lowest EDA levels were found in students with both ADHD and specific learning disabilities (Mangina & Beuzeron-Mangina, 2009). Students identified as having disabilities, it appears, are lower or deficient in their ability to attend, respond, and sustain orientation to a task (executive functioning).

Finally, other studies (albeit not studying adolescents with disabilities) investigating EDA level outcomes when participating in video game-like tasks found that the uncertainty of knowing what is going to happen next in a task—such as when an object on a screen is clicked—can momentarily increase EDA levels (Howard-Jones & Demetriou, 2008). This may suggest that the uncertainty in manipulating an exciting or interactive game-like task is related to a

higher emotional experience. Moreover, the higher momentary EDA level levels may increase engagement and attention to the task information. Perhaps the affective response to stimuli is important in improving learning outcomes (Howard-Jones & Demetriou, 2008).

A related literature base, using technology for students with severe and profound disabilities, has recently used EDA measures. Severe and profound disabilities can restrict one's interaction with an environment to eye or head movement or physiological responses like heart or respiration rate, electrodermal activity, or skin temperature. Blain, Chau, and Mihailidis (2008) identified electrodermal activity as a reasonable alternative pathway for providing access to an environment, which may allow students to participate in classroom and learning activities. Here, rather than serving as a physiological measure of response to stimuli, EDA may serve as an assistive technology accommodating for disability needs. In their review of accessible technologies for this population, Tai, Blain, Chau (2008) also identified EDA as a potentially reliable tool.

***Social-emotional aspects of learning.*** A considerable literature base links students' social and emotional connections to higher academic outcomes (Durlak, Weissberg, Bymnicki, Taylor, & Schellinger, 2011; Zins, Bloodworth, Weissberg, & Walberg, 2007). That is, students who have strong social and emotional connections care about learning and care about school. Besides simply measuring physiological responses to an environment, the Q-Sensor potentially serves as a mediator for feelings. In a recent meta-analysis, Durlak et al. (2011) synthesized the degree to which social and emotional learning (SEL) programs affect academics. The researchers found that SEL programs significantly improved academic outcomes. Moreover, an improvement of 11 percentile points in academic achievement was found when controlling for SEL programs. When students are provided with opportunities to be social—through motivation,

peer learning, and demonstrating of performance and competencies—these components appear to mediate better outcomes socially, emotionally, and academically (Durlak et al., 2011).

Students who are self-aware and confident in their learning goals, strategies, and challenges try harder and persist for longer (Caprara, Barbaranelli, Pastorelli, Bandura & Zimbardo, 2000) and may be able to manage executive functions like sustained attention better (Greenberg, 2006).

If positive social-emotional affective responses to learning do, in fact, contribute significantly to academic outcomes, it is imperative that researchers consider inclusion of such responses. As noted by Hawkins (1997), “An important task for schools and teachers is to integrate the teaching of academic and social and emotional skills in the classroom” (p. 293). Considering the research favoring social-emotional connections of learning, the Q-Sensor may also serve as a way to monitor and help interpret student responses to use of traditional textbooks and iPad iBooks. Thus, when combined with other data sources, EDA may prove helpful in understanding the complex workings of an intervention study for students with disabilities.

***Summary of EDA literature.*** A majority of recent studies using EDA as a dependent variable for SWD are not intervention studies. Furthermore, very few intervention research studies for SWD have measured the physiological and social-emotional aspects of classroom learning. Instead, studies have predominantly focused on understanding the characteristics of SWD compared to their peers without disabilities, in particular, measuring the EDA response levels of students with ADHD involved in a menial task, such as clicking a button on a computer screen. Further, EDA levels were often used in conjunction with other qualitative or quantitative measures such as error rates or listening tasks to triangulate executive functions or cognitive processes.

Electrodermal activity has multiple applications in educational research. As highlighted above, it has been used as a reliable response metric for executive functioning processes like attention and response time, and also may serve as a sensitive and valid accessible technology for students with severe or profound disabilities. The literature has also demonstrated that when paired with other physiological, qualitative, or quantitative measures, EDA can serve as a reliable methodology for interpreting specific tasks and behaviors of students and adults, both with and without disabilities. Thus, the data provided from EDA levels have been found to be valid, reliable, sensitive to small physiological changes, and valuable in understanding learning environments. EDA has not been broadly used in intervention studies. It would be useful and appropriate measure the effectiveness of interventions for SWD with electrodermal activity, in particular, social-emotional responses to learning and possible positive outcomes for academics.

**Summary.** Since the 1990s, a plethora of researchers have attempted to make sense of the different literacies and unique skills associated with technology-based learning (Cazden et al., 1996; Jewitt, 2008; Leu, Kinzer, Coiro, & Cammack, 2004; Leu et al., 2011; Mills, 2010). Commonly referred to as “new literacies,” “multiliteracies,” or “multimodalities,” the literacy experiences contextualized in the modern classroom now include not only words, but words in conjunction with audio, video, social interaction, and sense-making of the learning environment. When considering how to engage students and measure these social-emotional aspects of learning, the Apple iPad iBook holds promise for these endeavors. Potentially through use of physiological measures of electrodermal activity and the Q-Sensor, it may be possible to develop a classroom textbook that addresses these elements of new literacies. However, it is appropriate to now turn to instructional design of a textbook, an aspect noted in the literature as lacking “considerateness” in thoughtful creation (Armbruster & Anderson, 1998).

## **Elements of Good Design**

When developing a textbook, it is necessary, but not sufficient, to consider appropriate content. Instead, content may be thought of as only one-half of the textbook creation equation; it is equally important to consider the instructional design and layout of the textbook itself. Design of a textbook is a worthy consideration when working with students with specific learning disabilities. Students with SLD often experience compromised executive functions like organization, attending to important information, and decision-making (Anderson, 2002; Berkeley, Scruggs, & Mastropieri, 2010; Fagella-Luby & Deshler, 2008; Roberts et al., 2008). The following section considers the needs of this particular population under the umbrella of Universal Design for Learning (UDL). By doing so, UDL provides a framework from which to better understand how instructional design of textbooks may interact with the brain's functions. Finally, a framework for developing special education technology research is reviewed.

**Universal Design for Learning (UDL).** Some researchers in the disability literature have referred to structural components of learning under the auspices of the Universal Design for Learning (UDL) framework (Basham, Meyer, & Perry, 2010; Basham, Israel, Graden, Poth, & Winston, 2010; Rose & Meyer, 2000; Smith & Meyen, 2003). UDL considers the accessibility of text to be of paramount importance when developing content-area texts. Rose and Meyer (2000) argued that universal design in architecture allows persons with disabilities to access a building due to elevators, curb cuts, or ramps. Similarly, universal design in education attempts to provide access to learning (Rose & Meyer, 2000). Furthermore, "...it is not access to materials or information that defines UDL, but "access to learning itself" (p. 67).

When considering UDL in the classroom, content, assignments, and activities should be universally flexible to address two sets of differences: (a) individual differences and (b) media differences. UDL that considers individual differences accounts for a student's unique strengths, interests, needs, and areas of opportunity. To that end, textbooks should not provide one form or method of learning that limits learning options. Instead, they should carefully weigh opportunities to address these differences, such as Project 2061's criteria (e.g., taking account of student idea or promoting students' thinking about phenomena, experiences, and knowledge).

In terms of media differences, no single form of medium can be molded to fit all learners. Multiple means and methods allow all students to access content and demonstrate competency. To address these universally flexible differences, CAST, The Center for Applied Special Technology and the National Center on Universal Design for Learning, has outlined three principles for curriculum development:

1. The recognition or "what" of learning, including multiple means of representation using sensory abilities
2. The strategic or "how" of learning, including multiple means of action and expression using processes and tasks
3. The affective or "why" of learning, including multiple means of engagement using motivation and interest. (CAST, 2011, Guidelines Version 2.0)

UDL seeks to maintain high learning standards and academic outcomes for all learners through use of these three principles. Further, it proactively attempts to overcome barriers to learning (Basham et al., 2010). Given the findings of Project 2061 and considerations put forth by this group and other UDL researchers, it is important to design textbooks (both physical and virtual) to be more accessible for all learners.

**Summary.** The use of technology is an important element in the implementation and success of UDL (Basham et al., 2010; Rose & Meyer, 2000). Technologies in education have the potential to be sensitive to all three principles put forth by CAST. Technology allows for



multiple means of representation through various displays of information, such as auditory and visual learning, and various structural components like different languages and graphics, and supports multiple media formats. Technology also allows for multiple means of action and expression, such as navigation choices and assistive technologies and communications, and supports various practices and performances. Finally, technology allows for multiple means of engagement through choice, autonomy, goals and objectives, challenges, and different interests. The role of UDL in technology and the development of textbooks when considering instructional design is a natural progression. Moreover, one particular technology has surpassed desktop, laptop, and mobile phone sales as the most popular piece of technology on the planet: the iPad.

**Textbooks.** Textbooks serve as a “declarative knowledge” base for teachers (Snow, Griffin, & Burns, 2007). From textbooks, teachers form a core of knowledge to expand, grow, and learn while instructing students. Similarly, students gain foundational and necessary knowledge from textbooks to learn about the world.

Expository texts including physical (i.e., textbooks) and virtual (i.e., virtual) environments are used with high frequency. In fact, one study found that 96% of the text on the Internet was expository in nature (Kamil & Lane, 1998), and more recent reports and articles support this finding (Tilstra & McMaster, 2013; RAND Reading Study Group, 2002). In particular, a seminal piece noted that for students with poor reading skills or disabilities, textbooks often present no logical sequence or planning structure used to approach a text (Meyer, Brandt, & Bluth, 1980). Aggravating this challenge is the fact that current research suggests that effect sizes for expository text interventions are lower than narrative text interventions for the students who need the most help in learning (Edmonds et al., 2009). It is no surprise, therefore,

that for students with poor reading skills or disabilities, textbooks can be overwhelming. Without explicit instruction in how to navigate the world of a textbook, many students are lost.

When considering how to navigate a complex text, it is important to consider the structural components of a textbook. Structural components of textbooks refer to principles of design, including textbook instructional design, layout of content, or presentation of material (László, 2006; Mayer, 2009; Neř mcová, 2012). László (2006) succinctly summarized the concern about the complexity of textbooks as the difference between the “basic principles of structuring [learning] requirements” (p. 1), not the quality of the content. The design features of a textbook significantly influence a text’s effectiveness as a teaching and learning tool.

As Meyer et al. (1980) noted three decades ago (evidence since reinforced by Gajria, Jitendra, Sood, & Sacks, 2007; Jitendra, Burgess, & Gajria, 2011; Synder, 2010), struggling learners are not sufficiently prepared to address the varying structures found within content-area textbooks. Similarly, most curriculum materials are not structurally coherent or focused (Kesidou & Roseman, 2002).

Project 2061, an initiative founded in 1985 by the American Association for the Advancement of Science (AAAS), is made up of scientists and experts in the STEM fields (science, technology, engineering, and mathematics). AAAS conducted research into defining the criteria necessary for an effective textbook. The criteria framework outlined by Project 2061 sheds insight on how to build effective features into a textbook.

***Project 2061.*** Developed over three years in the early 21<sup>st</sup> century, Project 2061 created a procedure for examining the quality of instructional design within a textbook. The criteria, organized into seven categories, served as indicators of quality instructional design and support.

In evaluating textbooks, STEM experts used the criteria's indicators to determine if a given text was "Excellent," "Satisfactory," or "Poor." The categories are summarized below.

1. Providing a sense of purpose
2. Taking account of student ideas
3. Engaging students with relevant phenomena
4. Developing and using scientific ideas
5. Promoting students' thinking about phenomena, experiences, and knowledge
6. Assessing progress
7. Enhancing the science learning environment, (AAAS, Project 2061, 2002, *Criteria Used in Evaluating the Programs' Quality of Instructional Support*)

Using this benchmark-based evaluation, widely used STEM textbooks were analyzed.

Reports and articles from the group have shared the same broad finding; namely, textbooks provide weak instructional design and support for both students and teachers (Budiansky, 2001; Kesidou & Roseman, 2002; Kulm & Roseman, 1999; Roseman, Kulm, & Shuttleworth, 2001).

One researcher within Project 2061 noted, "No matter how scientifically accurate a text may be (from a content standpoint) if it doesn't provide teachers and students with the right kinds of help in understanding an applying important concepts, then it's not doing its job" (László, 2006, p. 6).

Significant shortcomings were found in commonly used biology textbooks, and nine middle school science programs included no instructional design that was likely to contribute to students' understanding and mastery of key scientific ideas (Kesidou & Roseman, 2002). Instead, textbooks were found to focus on vocabulary and factual information, rather than presentation and concentrated coverage of main ideas or important concepts.

In summary, research suggests that limited attention is paid by authors and publishers to the design of textbooks. Regardless, textbooks continue to be the most common form of acquiring information in schools. However, they have been found to be inaccessible for some students with learning difficulties and do not clearly emphasize information that is central to main ideas and concepts, ultimately suffering from a lack of cohesiveness (Kesidou &

Rosenman, 2002). When textbooks present external cues, like the highlighting of main ideas or important information, readers are able to predict a text's structure (Tilstra & McMaster, 2013). However, when deprived of quality textbook instructional design and structural integrity, textbooks become less predictable and unfamiliar, which can make reading comprehension difficult for both good and struggling readers.

**Mayer's cognitive theory of multimedia learning.** Mayer's Cognitive Theory of Multimedia Learning attempts to address Leu and colleagues' new literacies through his work in multimedia instruction (DeLeeuw & Mayer, 2008; Mayer, 2002, 2003, 2009; Mayer & Moreno, 2003). While new literacies theory outlines the set of skills and strategies necessary to access and learn using emerging technologies, Mayer's work addresses the components of instructional design and their effects on the brain. In short, Mayer has used presentation software (i.e., PowerPoint) to determine effective design principles. Through presentations of words and pictures, Mayer's work contributes significantly to the fields of textbook instructional design, UDL, and new literacies theory.

Cognitive workload hypothesizes that only a limited amount of resources are available within the brain to properly function and perform certain tasks (Chandler & Sweller, 1991; Sweller, 2006). Thus, if cognitive resources are used to address a particular aspect of reading, such as fluency, fewer cognitive resources are available to allocate towards comprehension (Rasinski et al., 2005). Furthermore, Mayer (2003) proposed that the brain has only limited resources to address components of multimedia learning. For example, a multimedia slide or PowerPoint presentation includes some combination of visuals, on-screen text, and spoken words. However, with a fixed amount of cognitive resources, students choose to focus on particular information within the multimedia presentation, disregarding other information.

Considering cognitive workload, Mayer attempted to address the unique combination of multimedia instructional design that affected learning outcomes. Mayer's models of multimedia learning are outlined below.

DeLeeuw and Mayer (2008) identified three elements of cognitive workload within a multimedia environment, and proposed that student-centered learning experiences, such as watching a multimedia presentation, force learners to make choices about their learning, including what to read, where to attend, for how long, and what to remember. The elements of the triarchic model of cognitive load include (DeLeeuw & Mayer, 2008):

1. Extraneous processing; in which the learner processes unnecessary content
  2. Essential processing; in which the learner processes essential content
  3. Generative processing; in which the learner engages in deep cognitive processing.
- (p. 223)

DeLeeuw and Mayer (2008) also identified ways in which cognitive workload may be manipulated. For example, extraneous processing may be reduced through non-redundant information, such as presenting concurrent information in animated and narrative forms, and may be increased through redundancy of identical animation, narration, and on-screen text. Response time to a task may be one measure of cognitive workload that is affected by this processing element.

Essential processing involves the formation of mental representations of content. This type of processing can be manipulated through sentence complexity, for example, and effort ratings may be one measure of cognitive workload affected by this processing element.

Finally, generative processing involves making connections of mental representations from the working memory to the long-term memory. This type of processing may be manipulated through problem-solving questions and activities, and difficulty ratings may be one measure of cognitive workload affected by this processing element.

The triarchic model of cognitive load proposes that cognitive workload is not a unitary construct, but composed of or influenced by different elements of processing (DeLeeuw & Mayer, 2008, p. 233). By framing learning as an active, resource-limited experience, it is possible to identify unique components of multimedia instruction that foster or hinder positive learning experiences.

Extending the triarchic theory of cognitive load, Mayer proposed the cognitive theory of multimedia learning (CTML; DeLeeuw & Mayer, 2008; Mayer, 2002, 2003, 2009; Mayer & Moreno, 2003). The CTML integrates the triarchic model, and includes 12 principles of design (see Table 1). Using presentation software, Mayer was able to isolate features of multimedia design and their effect sizes. In his book *Multimedia Learning* (2009), Mayer synthesized research conducted using the 12 principles of design.

Most of the studies conducted by Mayer and colleagues included participants at the college or postsecondary level, who did not have (or report) disabilities. However, considering that SWD may struggle with cognitive overload, it is appropriate to discuss features of instructional design that aid in appropriate levels of cognitive workload (Baddeley, 1986, 2008; Daneman & Carpenter, 1980; Johnson, Humphrey, Mellard, Woods, & Swanson, 2010; Swanson, Zheng, & Jerman, 2009).

Table 1

*Mayer's 12 Principles of Multimedia Design*

Principle	Effect Size
1. Coherence principle	0.97
2. Signaling principle	0.52
3. Redundancy principle	0.72
4. Spatial contiguity principle	1.19
5. Temporal contiguity principle	1.31
6. Segmenting principle	0.98
7. Pretraining principle	0.85
8. Modality principle	1.02
9. Multimedia principle	1.39
10. Personalization principle	1.11
11. Voice principle	0.78
12. Image principle	0.22

In summarizing his findings, Mayer (2009) identified 10 of the 12 principles as contributing to effective multimedia presentations. These include (a) coherence: minimizing extraneous text; (b) signaling: highlighting essential material; (c) redundancy: presentation via speech rather than speech and text; (d) spatial contiguity: presenting corresponding words and pictures near one another; (e) temporal contiguity: presenting corresponding words and pictures simultaneously; (f) segmenting: presenting information in segments rather than continuously; (g) pretraining: acquainting learners with relevant concepts and ideas; (h) modality: presenting words as speech rather than text; (i) personalization: using a conversational rather than formal style; and (j) voice: using a human rather than computer voice (p. 274).

To summarize, Mayer and colleagues demonstrated that significant effect sizes are found when students are able to focus on the most relevant and important content, free of superfluous and overly complex information. Furthermore, cognitive workload is not a singular construct, but one that is affected by a multitude of processing elements. When considering instructional

design, then, Mayer's principles of multimedia design may be useful. It is now appropriate to turn to ways in which content is being created and used in the classroom.

**Gersten and Edyburn (2005) quality indicators.** In 2005, Gersten and Edyburn outlined eight quality indicators for special education research using technology. Using the indicators, the authors provided a framework to enhance the evidence base for educational research and design of technology. Below the eight quality indicators are briefly summarized (pp. 6-11)

1. Conceptualization of the research study using an innovative approach that reflects the current knowledge base with a clear instructional design of the intervention
2. Full disclosure of conflicts of interest
3. Sample selection that is generalizable
4. Description of participants that includes sample selection and description
5. Implementation of the intervention includes clearly described technology components and fidelity checks
6. Outcome measures that are closely aligned with the intervention
7. Data analysis using an appropriate unit for each research question
8. Publication and dissemination that bridges the research-to-practice gap

As noted by Gersten and Edyburn, technology research and development has unique methodological design features that require careful consideration by researchers. The authors hypothesized that these recommendations may facilitate in shaping quality research on technology and ultimately, more effective classroom practices.

## **Summary**

This literature review highlighted three research areas. First, the interventions and instructional practices found to be most effective for SWD were discussed. The research suggested bridging the gap between learning to read and reading to learn, such as finding important information, and pairing reading with direct and explicit instruction. Then, new literacies theory was outlined, including various technologies, and the intersection of traditional, print-based literacies was contextualized with new forms of literacy and learning. The Apple iPad was identified as a



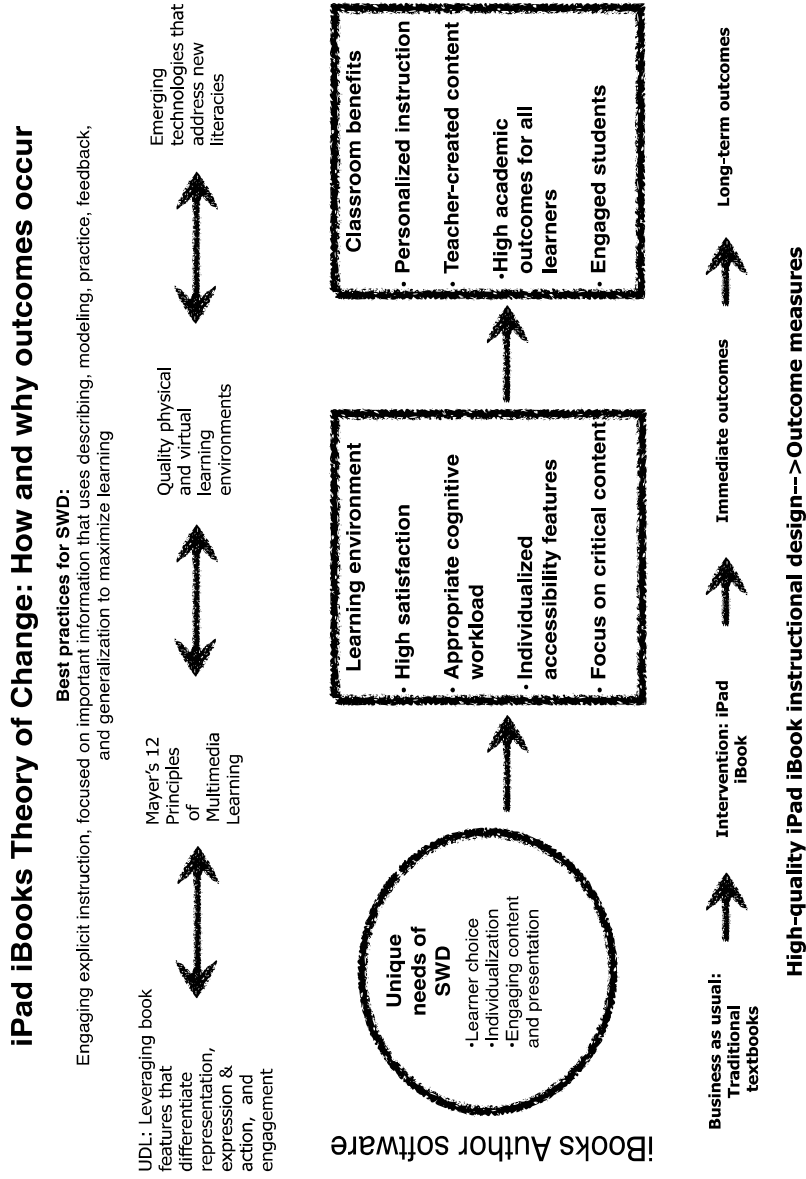
potential piece of technology that can personalize and individualize instructional environments through use of iBooks and iBooks Author. Finally, quality instructional design features were discussed through the lens of Universal Design for Learning and cognitive theory of multimedia learning. Finally, indicators of quality special education technology research was summarized.

### **Theory of Change**

Figure 1 illustrates a proposed theory of change. A theory of change may be thought of as a combined conceptual framework and logic model (Kagan, 2008; Patton, 2008). A logic model becomes a theory of change when it hypothesizes the causal mechanisms at work in creating the desired outcomes. In this study, this is described as the unique needs of SWD and how the iPad iBook may address these needs, thereby improving reading outcomes through book features, cognitive workload, instructional design, and accessibility. These mechanisms lead from the proposed components of the intervention to short-term or immediate expected outcomes, to intermediate results and finally to longer-term outcomes.

In the iPad iBooks theory of change—how and why outcomes occur, the three critical aspects of the iPad iBook—are outlined at the top, grounding the intervention. These aspects are instructed using best practices for students with disabilities. In the middle, the use of the iBooks Author software allows the teacher to address the unique needs of students with disabilities. As the intervention is taught, short-term learning environment and long-term classroom benefits are noted. In other words, a theory of change is a logic model with additional theories that attempt to explain how the intervention works.

Figure 1. iPad eBooks theory of change.



**Gaps in the literature.** No empirical, peer-reviewed studies using an iPad as a classroom textbook were identified for this review. Of the studies that do exist, few used an experimental design, and none focused on students with SLD. Given that many school districts and states in this country have committed millions of public dollars, and in the case of Los Angeles Unified School District, \$1 billion, to using the iPad as an instructional tool, it is important that more research using this technology be conducted. Therefore, the dearth of published, peer-reviewed research on this topic presents a significant opportunity to combine the iPad iBook the iBook Author software with an intervention addressing the needs of SLD.

### **Statement of Purpose for an iPad iBook Intervention**

Research has shown that SWD, specifically those with SLD, benefit from individualized instruction that is accessible in multiple formats (Berkeley et al., 2010; Deshler & Hock, 2007; Deshler & Schumaker, 1986; Edmonds et al., 2009; Swanson, 1999b). Learning potential is maximized when framed by a teacher using explicit instruction that is described, modeled, practiced, and provides feedback and generalization opportunities (Archer & Hughes, 2010; Fagella-Luby & Deshler, 2008; Schumaker & Deshler, 2009; Sencibaugh, 2007). Furthermore, new technologies that leverage interactivity engage students to experience content in an exciting way (Durlak et al., 2011; Leu et al., 2011; Leu et al., 2004; Zins et al., 2007). To that effect, many have hypothesized that the iPad is an engaging, enjoyable, and exciting tool of instructional technology (Gertner, 2011; Hu, 2011; Wood, 2013).

However, when considering the instructional design and features offered in a textbook or iPad iBook, to date little research has addressed reading comprehension scores and cognitive workload. This study was an attempt to address this limitation and add to the literature base in this growing field.

The research questions and design of this study are grounded in the review of three factors: (a) effective interventions for SLD, (b) current learning environments, and (c) emerging technologies. The dearth of published, peer-reviewed research on this topic presents a significant opportunity to combine the iPad iBook Author software with an intervention that addresses the needs of SLD. Therefore, this study was designed to assess the promise of the iPad iBook holds for addressing the unique needs of SWD.

### **Research Questions**

1. Is there a difference in the reading comprehension scores of students with disabilities when using traditional textbooks compared to iPad iBooks?
2. Is there a difference in the electrodermal activity (EDA) levels of students with disabilities when using traditional textbooks compared to iPad iBooks?
3. Is there a difference in the amount of cognitive workload of students with disabilities when using traditional textbooks compared to iPad iBooks?
4. To what extent are students with disabilities who are taught features of traditional textbooks and iPad iBooks satisfied with each format?
5. What do students with disabilities report as being the most (least) helpful features, and how would they prefer to use traditional textbooks and iPad iBooks?

## CHAPTER III

### METHODS

Many school districts have recently purchased iPads for use in classrooms, yet there is little empirical research to back their use for classroom instruction (Apple, 2013; Blume, 2013a, 2013b, 2013c; Wood, 2013; Yaccino & Rich, 2013). This intervention study employed a mixed-methods experimental counterbalanced design to teach students with disabilities to identify and understand features of traditional textbooks and iPad iBooks. Quantitative and qualitative research methodologies were used to collect data, and through triangulation of data, strengthened the validity of the study (Fraenkel & Wallen, 2006).

The study took place in a school setting in a large metropolitan city in the Midwest during the spring of 2013. The University of Kansas Human Subjects Committee granted permission to conduct the research. Furthermore, permission was granted from parents or guardians through written informed consent and student oral assent. The participating school, a private school for students with disabilities, provided demographic information and data regarding individualized education programs (IEPs), IQ scores, disability diagnoses, and prescribed medications. Other data were collected by means of electrodermal activity (EDA) monitoring, semi-structured audio interviews, reading assessments, and survey instruments. Data were collected over eight sessions from 22 participants.

#### **Participants**

**Teachers.** The researcher was a middle school teacher at the school where the study took place. A licensed special education teacher in adaptive education grades K-6 and 6-12, the researcher had taught grades 4-8 for three years at the participating school. Furthermore, the researcher held a bachelor's degree in child development and a master's degree in special

education, and at the time of the study was a doctoral candidate in special education. The teacher is identified as “researcher” in subsequent discussions.

The researcher recruited as a research assistant a school faculty member who expressed an interest in improving reading outcomes for middle school students with disabilities. This faculty member, who held a bachelor’s degree in cognitive psychology, was the technology director at the participating school; he had worked in schools for four years, taught technology-related classes, and served as operations and development coordinator for a national teaching organization in schools and classrooms. He was present for all intervention sessions. The faculty member is identified as “research assistant” in subsequent discussions.

**Students.** All middle school students grades 4-8 enrolled at the school ( $N = 45$ ) were invited to participate in the study. With approval from the school principal, an initial inquiry letter was sent home with eligible students. A total of 22 students participated in the study. A random number generator was used to assign students into one of two cohorts until a balance of 11 students in each cohort was achieved. The sample included 7 females and 15 males, ranging in age from 10 to 15 years old ( $M = 12.64$ ;  $SD = 1.47$ ), in grades 4 to 8 ( $M = 6.55$ ;  $SD = 1.34$ ). Nineteen of the 22 students identified themselves as Caucasian, with 2 identifying as Hispanic, and 1 identifying as African-American and Hispanic. All participants were receiving special education services at the time of the study, and had a current IEP. Three participants were identified under the label of autism spectrum disorder (ASD), 1 under emotional disturbance, 1 under intellectual disability, 4 under other health impairment, and 13 under specific learning disability. Nineteen had taken a general intelligence test within the last three years and had mean scores of 97.84 ( $SD = 13.23$ ). For three participants, no IQ measure was available. IQ scores of the two cohorts were compared using an independent-samples  $t$ -test, which determined that no

significant mean differences existed between the two cohorts,  $t(17) = 1.49, p = 0.156$ . Table 2 presents the demographic data for student participants.

Table 2

*Participant Demographic Data*

Category	Identifier	Cohort A	Cohort B	Total
Gender	Female	27%	36%	32%
	Male	73%	64%	68%
Age	<i>M (SD)</i>	12.82 (1.60)	12.45 (1.37)	12.64 (1.47)
Ethnicity	Caucasian	9	10	19
	Hispanic	2	---	2
	Other (two or more)	---	1	1
Disability Type	Autism	---	3	3
	Emotional Disturbance	1	---	1
	Intellectual Disability	---	1	1
	Other Health Impairment	1	3	4
	Specific Learning Disability	9	4	13
	ADD or ADHD Diagnosis	73%	64%	67%
	IQ Score	<i>M (SD)</i>	102.44 (8.90)	93.70 (15.48)

*Note.* ADD = attention deficit disorder; ADHD = attention deficit hyperactivity disorder.

**Setting**

Two settings were used during the study. A private school in a large metropolitan midwestern city served as the setting. The school served students grades 1-12, was fully

accredited by three separate and independent agencies, and had an average enrollment of 65 students over the past five years. The school primarily served students with disabilities; each child was served under an IEP. Students averaged 1½ to 2 years of enrollment before transitioning to a more traditional school setting.

**Classroom setup.** The study took place in one classroom within the school. Participants were familiar with the room and had previously worked there. The classroom was furnished with two chalkboards and four individual desks; it had bright lighting and large windows. Located at the end of a hallway, the room was in an undisturbed part of the school with minimal foot traffic. During instruction and data collection, the classroom door was closed, and the room was quiet. Two instructors (i.e., the researcher and the research assistant) were present during instruction.

At each desk, students were provided the following: a pencil, a colored highlighter, headphones, a Q Sensor (a device used to measure electrodermal activity), an iPad 2 with full-sized 9.7 inch screen, and a binder containing instructional materials. The binder and associated materials were labeled with an identification number unique to each participant. Materials and data were stored in the room behind a locked classroom door and security school door.

**Scheduling.** Families and students signed up for eight individual sessions, each scheduled for one hour. In the morning, sessions ran immediately prior to school starting, from 7:30-8:30 a.m. In the afternoon, sessions ran immediately after school, from 2:30-3:30 p.m. Alternate setting sessions took place on the weekend and were individually scheduled with families on an as-needed basis.

### **Intervention Components**

This investigation employed an intervention designed to study the effects of an iPad iBook on reading comprehension, student engagement, and electrodermal activity. Participants



were separated into two cohorts (i.e., Cohort A and Cohort B) and each read one of two book treatments: a traditional science textbook or an iPad iBook. The traditional textbook treatment served as traditional textbook (TT) in a classroom, and the iPad iBook as the intervention.

Although the iPad iBook served as the “intervention,” it was necessary to first teach participants how to effectively read and comprehend from an unfamiliar device. Two lessons were dedicated to this instruction. To ensure that all participants had knowledge of each of the main features available in each treatment medium (i.e., the traditional textbook or the iPad iBook), an orientation session was conducted. Furthermore, to best test the actual effects of treatment medium types on reading comprehension, electrodermal activity, and student engagement, the FI<sup>3</sup> was taught to ensure that participants understood and could fully use any learning feature of the treatment medium as they navigated through it. The Finding Important Information Intervention (FI<sup>3</sup>) was critical to help students formally organize how and what they were to use to optimally benefit from the treatment medium they were using. Developed by the researcher, the FI<sup>3</sup> was designed to provide a common understanding that enabled participants to learn specific book features that aided them in identifying critical information in their content area text. Two hour-long lessons were committed to instruct the FI<sup>3</sup>. Finally, the FI<sup>3</sup> was reviewed during a 2-3 minute priming activity at the start of each of the eight lessons. Thus, the FI<sup>3</sup> served as the central part of the overall intervention.

Once participants met an established set of criteria demonstrating that they were familiar with the key text features taught through the FI<sup>3</sup>, it was assumed that they were sufficiently prepared to use both book types. In developing the iPad iBook for this study, it was imperative to create a parallel text that contained the same content as the traditional textbook. Particular

attention was given to the inclusion of equivalent content in the iPad iBook development. Thus, titles and headers, graphic captions, and vocabulary words were identical in both book types.

In light of Clark and Kozma's well-documented 1994 debate regarding media and technology (Clark, 1994; Kozma, 1994), it was essential that any effects found from the iPad iBook treatment not be obstructed due to differences in the book type content, but rather differences in the media treatments. As scientists in the fields of education and technology, Clark (1983) and Kozma (1994) wrote position papers regarding the influence of media on the role of learning. Clark (1983) stated that media are "mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 445). Conversely, Kozma (1994) noted that rather than separating media from method (i.e., teaching pedagogy), an integral relationship of the two is quality instructional design. To that end, this study reflected sensitivity to creating analogous book content while enhancing the iPad iBook using a sound instructional design. The methodology for such a design is outline below.

**The Finding Important Information Intervention (FI<sup>3</sup>).** As part of the iPad iBook intervention, participants were instructed on how to effectively use a non-fiction book. The purpose of the readiness intervention was to establish uniform, shared knowledge about how to use both a traditional textbook (TT) and the iPad iBook. After learning the FI<sup>3</sup>, participants alternated treatments between TT (i.e., a traditional science textbook) and an iPad iBook.

Using the FRAME (Ellis, 1998) graphic organizer as a guide, participants were able to use the 7 traditional textbook features or 10 iPad iBook features to achieve higher reading comprehension. Book features are outlined in the section Features. In total, two 60-minute lessons were devoted to instructing students about the FI<sup>3</sup>, and three 60-minute lessons were

devoted to reading each book type for a total of eight 1-hour lessons. Table 3 lists the structure of the cohort instructional sequence.

Table 3

*Cohort Instructional Sequence*

Cohort	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8
Cohort A	FI <sup>3</sup>	TT	FI <sup>3</sup>	iBook	TT	iBook	TT	iBook
Cohort B	FI <sup>3</sup>	iBook	FI <sup>3</sup>	TT	iBook	TT	iBook	TT

*Note.* TT = traditional textbook

The FI<sup>3</sup> was designed to explicitly teach participants (a) book navigation, (b) critical textbook characteristics (e.g., table of contents, glossary), and (c) shared and unique structural features of both traditional textbooks and iPad iBooks. Grounded in research, the FI<sup>3</sup> specifically incorporated the following literacy and pedagogic components for enhancing reading comprehension: (a) graphic organizers (Dye, 2000; Ellis, 1998; Hall & Strangman, 2002); (b) practice and feedback (Archer & Hughes, 2010; Deshler & Schumaker, 1986; Deshler et al., 2001; Swanson & Lussier, 2001); (c) multimedia learning (Mayer, 2009); and (d) Universal Design for Learning (Basham, Meyer, & Perry, 2010; Rose & Meyer, 2000). Over two 60-minute lessons, participants learned common book features in preparation for the study, which compared traditional textbooks to iPad iBooks.

**Features.** For the FI<sup>3</sup>, the researcher taught participants the 7 traditional textbook features and the 10 iPad iBooks features (Table 4). Commonly referred to as “cognitive strategies,” “study habits,” or “active reading,” the features of a textbook address the unique characteristics of texts that promote improved reading comprehension. Robinson (1941, 1970) developed one of the most widely used reading strategies, SQ3R, or Survey, Question, Read, Recite, and Review.

The SQ3R and its derivatives (e.g., Survey, Question, Read, Write, Recite, Review [SQ4R]; Preview, Question, Read, Self-recitation, Test [PQRST]; Know, Want, Learned [KWL]) are reading comprehension strategies designed to master complex texts.

While few empirical studies have validated the effectiveness of the SQ3R strategy (Huber, 2004), others have noted that cognitive strategies have promise for developing independent student use, increasing recall, and facilitation of student role and responsibility in the process of learning (Bakken, Mastropieri, & Scruggs, 1997; Carlston, 2011; Huber, 2004). Using the literature base grounded in this work, the researcher identified features of both book types were identified by the researcher. Table 4 provides a comparison between the features found in traditional texts compared to iPad iBooks.

Table 4

*Features of Traditional Textbooks and iPad iBooks*

Traditional Textbooks	iPad iBooks
Table of contents	Table of contents
Glossary & vocabulary	Glossary & vocabulary
Text clues (bold, italic, underline, font, color, size)	Text clues (bold, italic, underline, font, color, size)
Cues (You Are There!)	Cues (You Are There!)
Pictures	Pictures
Highlighting & note taking	Highlighting & note taking
Reviews	Reviews (2)*
---	Video (1)*
---	Interactivity (2)*
---	Audio (1)*

\*Feature exclusive to the iPad iBook condition.

A brief summary of each feature follows:

- *Table of contents*—denotes main sections or divisions within a book; helped organize content; examples included the index, chapters, and the glossary
- *Glossary and vocabulary*—a listing of important terms and definitions; identified essential content; examples included scientific theories and ideas
- *Text clues*—distinctive changes that emphasize text; drew the reader to specific content; examples included bold, italic, underline, font, color, and size changes
- *Cues*—text segmented from other material; invited the reader to learn a topic closely related to the core material; example included *You Are There!*, an imaginative trip to an Alaskan stream
- *Highlighting and note taking*—the use of writing utensils to mark important information; actively engaged student in identifying information; examples included a yellow highlighter or writing notes in the margins
- *Reviews*—end-of-section or chapter summative comprehension questions; asked reader to assess material; examples included “Can you identify the four steps ...”
- *Video*—clips of moving visual images with audio; an opportunity to experience content in a different format; examples included videos of properties of matter
- *Interactivity*—the look and feel of a system’s user interface (UI) embedded as learning widgets; asked the reader to participate in a physical activity; examples included matching or multiple choice questions

- *Audio*—recorded sound clips; using headphones, allowed reader to listen to text; examples included sounds of wildlife

***iBooks Author.*** Further enhancing the Apple iPad hardware and App Store software, Apple released the iBooks Author software in early 2012. A powerful software package designed to create electronic books (eBooks), iBooks Author is educator-friendly and -focused, providing templates and tools that allow significant flexibility in creating a book with unique features. Thus, authors can control many facets of a book, including text, colors, imagery, graphs and charts, and widgets. A widget, as defined by Merriam-Webster is “an unnamed article considered for purposes of hypothetical example” (2013). Within iBooks Author, standard widgets include gallery, media, review, Keynote, interactive image, 3D, scrolling sidebar, pop-over, and HTML. Authors may publish their book on the Apple App Store, charging a fee or releasing it free to the public. In short, iBooks Author provides classroom teachers with the tools to develop and publish their own textbooks.

***Traditional textbook.*** For purposes of this study, the researcher identified an appropriate-level content-area textbook that served as the control condition, or traditional textbook, in a classroom. Specifically, the text *Science* (2006) was cited by the publisher, Scott Foresman for Pearson Education, Inc., as being a comprehensive series appropriate for students studying science in middle school grades. The texts in the series consist of four separate books: *Life Science*, *Earth Science*, *Physical Science*, and *Space and Technology*. Each was determined to be an appropriate text, given that participants in the study were aged 10-15 and in grades 4-8 studying science on a daily basis.

In developing a parallel iPad iBooks textbook, the researcher included all content for six chapters of the book. The content-area material in each chapter was non-overlapping, allowing

students to learn each chapter without knowledge of previous chapters. The topics in the six chapters were the following: (a) *Life Sciences: Plants and how they grow*, (b) *Earth Sciences: Water*, (c) *Earth Sciences: Weather*, (d) *Physical Sciences: Matter and its properties*, (e) *Physical Sciences: Forces and motion*, and (f) *Science and Technology: Patterns in the sky*. The iPad iBook created included the same information and content as the traditional textbook, such as vocabulary and glossary terms, relevant theories and activities, as well as similar pictures and graphics. Also, summative review questions found within the chapters in the traditional textbook were the same in the iPad iBook. Finally, end-of-chapter tests found in the traditional textbook were used to demonstrate reading comprehension for both book treatments.

***Unique iPad iBooks features.*** While the content from the traditional textbook in the iPad iBook was consistent throughout, the researcher enhanced the iPad iBook using features that are unique to the iPad iBook technology. For instance, while a picture of a sunflower was presented in *Life Sciences: Plants and how they grow*, the iPad iBook technology allowed for a more interactive display of imagery. As a result, instead of one sunflower picture, the iPad iBook contained a series of sunflowers and related pictures that could be enlarged and flipped through. The researcher used evidence from the research literature to identify features (Table 4) that have been found to have an impact on learning and comprehension (Hattie, 2009; Mayer, 2009; Rose & Meyer, 2002).

Parameters were set for creating each iPad iBook chapter, and through these decision rules of instructional design, it was determined that each chapter would include (at a minimum) the following iPad iBooks-specific features (or widgets): two review opportunities, one video segment, two interactive widgets, and one audio segment. The research assistant completed a fidelity checklist to confirm that these rules for instructional design within the iBook were

consistent. Interrater reliability was confirmed to be 100%. The fidelity checklist for the iPad iBooks Instructional Design Rules is located in Appendix B.

**Summary of treatments.** To simplify instruction and help sustain attention and engagement, students were taught each treatment over two 60-minute lessons rather than one 120-minute lesson. The TT, traditional textbooks, was identified as most closely aligned with genuine instruction in a middle school classroom using grade-appropriate content. A counterbalanced design, as noted in Table 3, was used to minimize variance associated practice effects. Furthermore, by alternating treatments (i.e., Lessons 4, 6, 8 in Cohort A and Lessons 2, 5, 7 in Cohort B), variance associated with chapter order was minimized.

**Student materials.** Each student was assigned a unique identification number, which was used throughout the study to label materials rather than using the student's name. Students had their own copy of the textbook, consisting of the six chapters copied, hole-punched, and organized in a binder in same fashion as the textbook. At their desks, participants were provided the following: a pencil, a colored highlighter, headphones, a Q Sensor, an iPad 2 with full-sized 9.7 inch screen, and the 3-ring binder. Within his or her 3-ring binder, each participant had a folder with the following materials:

- The FRAME graphic organizer
- The General Self-Efficacy Scale (GSES)
- Three student satisfaction surveys
- Colored table of contents and glossary
- Three colored textbook chapters
- Six colored reading comprehension tests
- Lined loose-leaf paper

### **Measurement Instruments**

Quantitative and qualitative data sources were used for the study. Quantitative data sources included: (a) reading comprehension test scores as the measure for read or learned



material, (b) electrodermal activity (EDA) as a physiological measure of affective response while reading, (c) the General Self-Efficacy Scale (GSES) as a measure of self-efficacy and coping, (d) the NASA Task Load Index (TLX) as a measure of cognitive load, and (e) student satisfaction surveys. Qualitative data sources included two semi-structured audio interviews and survey data. Each data source is described below.

**Reading comprehension tests.** Upon independently reading a book chapter, students completed a publisher-made reading comprehension test found at the end of the traditional textbook chapter. The test consisted of multiple-choice, matching, and short essay questions, varying from 13 to 18 questions. Students completed three reading comprehension tests from each book treatment, for a total of six.

The textbook publisher, Scott Foresman for Pearson Education, Inc., provided scoring procedures in a teacher's edition book; those procedures were followed. For scoring of the short answer questions, the researcher and research assistant independently scored answers to each question on a scale ranging from 0 to 2, using the teacher's edition book as a guide. 0 points reflected an answer that was completely incorrect, 1 point reflected an answer that was partially correct, and 2 points reflected an answer that was completely correct.

An interrater reliability of 100% was achieved through discussion of each item until an agreed-upon score was reached. For each reading comprehension test, means and standard deviations were found. A repeated measures design was conducted to book treatment differences. A sample of a comprehension test is located in Appendix C.

**Q Sensor.** Data captured by a Q Sensor, referred to as electrodermal activity (EDA), enabled the researcher to objectively measure students' bodily responses to a variety of emotional, cognitive, and physical experiences while reading (Affectiva, Inc., 2013; Picard,

2013). The Q Sensor, a wearable wrist device developed by Affectiva, a Massachusetts Institute of Technology-Science (MIT)-based company, is designed to "digitize emotion" by measuring participants' emotional arousal related to excitement, attention, anxiety, boredom, and relaxation. With the Q Sensor, it is possible to record skin conductance, skin temperature, heart rate, and physical movement and acceleration along the x-, y-, and z-axis of the wrist. Using these measures, observations, analyses, and comparisons of the two book type conditions were possible.

EDA data were observed in response to unique actions participants performed during book usage. When participants performed a specific action in a book, such as highlighting important text, their arousal systems demonstrated reactions (but with less severe consequences) similar to animalistic "fight or flight" examples. Furthermore, a participant observing a picture of a sunflower in a traditional textbook may demonstrate a different EDA level than when observing the same sunflower picture in an iPad iBook. Considering that Hill, Berthoz, and Frith (2004) found that nearly 85% of high-functioning adults with autism spectrum disorder (ASD) suffer from slight or severe impairments in alexithymia, or difficulty in cognitive processing of emotions, the use of EDA levels to quantify emotion was an important component when studying students with disabilities. Currently, many clinical studies involving students with ASD and related disabilities have used the Q Sensor as a viable measure of electrodermal activity (Affectiva, Inc., 2013). Because of its sensitivity to these types of actions, EDA as a metric for measuring participant emotional arousal was considered a sensitive measure of emotion, cognition, and attention in this study.

Poh, Swenson, and Picard (2010) published the most widely cited reliability and validity study of a precursor to the Q Sensor, the iCalm. The iCalm, with identical analog sensing

circuitry, was also developed at MIT and used as a physiological sensor. Through cognitive, physical, and emotional tasks, reliability correlation coefficients were found to be between 0.93 and 0.99 and significant at the  $p < 0.0001$  levels. Finally, valid measurements were produced from forearm use of the Q Sensor in real-world environments for the first time using this technology.

To measure EDA levels, means and standard deviations for each participant were compiled. A repeated measures design was conducted to investigate book treatment differences. A sample of an EDA data output file is located in Appendix D.

**General Self-Efficacy Scale (GSES).** This 10-item psychometric scale of perceived self-efficacy and coping across multiple demands was administered at the beginning of the study. The GSES (Schwarzer & Jerusalem, 1995) is scored on a 4-point Likert scale, ranging from “Not at all true” (1”) to “Exactly true” (4) and summed to a maximum score of 40. The questions are related to participants’ ability to solve problems, cope with adversity, accomplish goals, deal with unexpected events, resourcefulness, and problem solving (Schwarzer & Jerusalem, 1995). The scale has been translated into 31 languages and used with hundreds of thousands of children and adults.

Samples across various languages and nations identified a measure of internal reliability, Cronbach’s alpha, as ranging from .76 to .90. Positive criterion-related validity coefficients were found for favorable emotions, dispositional optimism, and work satisfaction. Negative coefficients were found for depression, anxiety, stress, burnout, and health complaints (Schwarzer, Bäßler, Kwiatek, Schröder, & Zhang, 1997). For each subscale item, means and standard deviations were determined. Independent sample  $t$ -tests were conducted to investigate participant differences. A sample of the scale is located in Appendix E.

After completing the reading comprehension tests, participants completed one of two posttest measures: the NASA-TLX cognitive load measure or the student satisfaction survey. Randomized within each cohort, each of these measures was administered three times.

**NASA Task Load Index (TLX).** Originally conceived as a way to operationalize human error when operating space equipment, the National Aeronautics and Space Administration (NASA) and other governments have used the TLX to understand specific environmental demands on cognition and cognitive load (Hart & Staveland, 1988). Developed in 1988, the subjective workload assessment measures overall workload. The TLX subscales include Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort and Frustration. Participants rate an experience on a 0 to 100 scale from Low/High or Poor/Good, and a weighting procedure is used to combine the six individual subscales into one global score of workload.

Hundreds of studies have demonstrated the utility of this instrument in measuring workload to facilitate an understanding of the complex roles of human and machine systems (Hart, 2006). For example, in evaluating cognitive load instruments, Rubio, Díaz, Martín, and Puente (2004) found significant Pearson correlation coefficients (i.e., 0.65 to 0.98) for the TLX, demonstrating high convergent and concurrent validity. Additionally, workload demand scores were found to be highly reliable for the instruments. Other researchers (Xiao, Wang, Wang, & Lan, 2005) have found Cronbach's alpha reliability scores for the TLX greater than 0.80. Although the NASA-TLX has demonstrated sensitivity in a wide array of human-machine contexts, few examples of its use with students with disabilities exist. Related, Noyes, Garland, and Robbins (2004) investigated paper vs. computer assessments for young adults and found that computer-based assessments may be more demanding than the paper counterpart.

For this study, the NASA-TLX was administered immediately after students had completed the three reading comprehension tests. The measure took 2-3 minutes to administer on a large computer screen and was completed with the researcher or research assistant providing oral reading assistance. Means and standard deviations for each subscale and overall workload were found. Independent sample *t*-tests were conducted to investigate book type differences. A sample of the survey is located in Appendix F.

**Student satisfaction surveys.** The other posttest measure, a satisfaction survey, was developed specifically for this study. Asking students to rate their attitudes toward each textbook treatment, this measure was administered immediately following the chapter reading comprehension test for a total of three satisfaction surveys for each participant. The survey consisted of seven questions rated on a 6-point Likert scale, ranging from “Completely dissatisfied” (1) to “Completely satisfied” (6). The questions related to participants’ understanding of the content, ease of use, ability to find the main idea, paraphrasing the chapter, using the textbook in other classes, using the textbook independently, and overall satisfaction. The means and standard deviations for each question and overall satisfaction were found. Independent sample *t*-tests were conducted to investigate book type differences. A sample of the survey is located in Appendix G.

**Audio interviews.** Two semi-structured interviews were also conducted and recorded using an audio recorder. The first, which took place prior to students beginning the first chapter of the study, included questions related to participants’ prior use of iPad iBooks and other eBook technologies. The second interview took place upon completion of the study; it included questions related to the participants’ thoughts and feelings about the intervention, including preferences about specific features of traditional textbooks and iPad iBooks. Participants were

asked to identify features they found useful and not useful, features they used the most and least, implications for learning in the classroom, and how they may use both book types in their future education. Audio interviews were transcribed by the researcher and coded for themes. A sample of guided questions is located in Appendix H.

**Fidelity checks.** As noted above in the section entitled Unique iPad iBook Features, a fidelity check was developed for the iPad iBooks Instructional Design Rules. The research assistant confirmed that instructional design rules were followed during the creation of the iPad iBook, and agreement with both the researcher and research assistant was found to be 100%. A sample of this checklist is located in Appendix B.

**Reliability.** A protocol for instruction of the features of books was developed and used by the researcher. This five-page document outlined the describing, modeling, and practicing stages of instruction during Lessons 1 and 3. The researcher followed the protocol during Lessons 1 and 3. During subsequent lessons (i.e., lessons 2, 4-8), the protocol was used to review each feature prior to instruction. A sample of this protocol is located in Appendix I.

## **Procedure**

Each student was randomly assigned to either Cohort A or Cohort B, treatment. Groups were balanced with 11 participants each. Within each cohort, textbook treatment was alternated. For instance, a participant in Cohort A would read *Chapter 1: Plants and how they grow* in a traditional textbook, then *Chapter 5: Water* in an iPad iBook, and so on. Administration of the NASA-TLX and the satisfaction survey was also randomized within each cohort, reducing the variance associated with specific assignment to the cohort or chapter condition. Randomization was performed using a random number generator.

Upon completion of the study, each participant received three traditional textbook treatments, three iPad iBook treatments, three NASA-TLX surveys, and three satisfaction surveys. Table 5 outlines the science book chapters, content, and an administration schedule of measures.





Table 5

*Lessons, Science Content, and Schedule of Measures*

Lesson	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8
Science	Instruction	Plants and	Instruction	Water	Weather	Matter and	Forces and	Patterns in
content		how they				its properties	motion	the sky
		grow						
Cohort A	$F1^3$	TT	$F1^3$	iBook	TT	iBook	TT	iBook
Measure	---	NASA-TLX	---	Satisfaction	Satisfaction	NASA-TLX	NASA-TLX	Satisfaction
Cohort B	$F1^3$	iBook	$F1^3$	TT	iBook	TT	iBook	TT
Measure	---	Satisfaction	---	NASA-TLX	NASA-TLX	Satisfaction	NASA-TLX	Satisfaction



**The FI<sup>3</sup> instructional lessons.** The researcher developed a protocol for instruction of book features, following the principles of explicit instruction and instructional sequencing. Archer and Hughes (2010) noted that high-quality effective explicit instruction consists of six principles: (a) optimized engaged time, (b) promoting success, (c) opportunity to learn, (d) grouped instruction, (e) scaffolded instruction, and (f) different forms of knowledge (pp. 4-12).

Furthermore, the explicit instruction methodology used in this study was developed and validated by the University of Kansas Center for Research on Learning (KUCRL). Specifically, research has shown that when a specific instructional sequence is used, outcomes for students with learning disabilities can improve (Schumaker & Deshler, 2009). The stages of instructional sequence outlined by the KUCRL are as follows:

- *Prestest* student skills
- *Describe* the purpose and rationale of the intervention to students
- *Model* the metacognition during use of the intervention
- *Verbally practice* the steps of the intervention
- *Controlled practice* with guided materials and feedback to achieve success
- *Advanced practice* with more challenging materials
- *Posttest* student skills
- *Generalize* the intervention to multiple settings

A protocol was developed to guide participant learning. Within the protocol, components of the Cue-Do-Review model were used (Boudah, Lenz, Bulgren, Schumaker, & Deshler, 2000; Deshler et al., 2001). In detail, *Cue* asks teachers to introduce a concept and the new information to previously learned information; *Do* asks teachers to use Linking Steps (i.e., introducing, using and expanding, gaining closure) to present content in an interactive manner, and *Review* asks teachers to check for student understanding. During Lesson 1, students were instructed using this protocol to learn about their first textbook treatment. For Cohort A, this was the traditional

textbook; for Cohort B, it was the iPad iBook. After completing Lesson 2, Lesson 3 introduced the alternate textbook treatment. A sample of this protocol is located in Appendix I.

Within lessons 1 and 3, participants first learned about the specific features of a book. Using their own traditional textbook or iPad, students followed along as the researcher identified and described textbook features. Student responses and ideas of what book features were critical to finding important information were recorded on a chalkboard. Next, the researcher and students co-constructed a FRAME Routine, a graphic organizer routine designed to arrange content in a logical and visually appealing manner (Ellis, 1998). Finally, the researcher created a completed FRAME and used it as a guide for all students. In detail, at the top of the FRAME, the Key Topic was completed as “A book feature,” and the linking sentence, starting with “is about ...,” was completed as “finding important information in a book.” Two Main Idea labels were completed as “textbooks” and “iPad iBooks.” The following line items for each book type listed the 7 traditional textbook and 10 iPad iBook features. At the bottom of the FRAME, a prompt asks “So What? (What’s important to understand about this?) and was completed as “It is easier to find information using book features.” The FRAME Routine was stored in the participants’ folder and prior to beginning each lesson. A sample of a blank FRAME is located in Appendix A.

***Task analysis checklist.*** To demonstrate competency in understanding and using textbook features, a checklist was developed. The Features of Traditional Textbooks Task Analysis Checklist and The Features of iPad iBooks Task Analysis Checklist were used twice each with each participant. Each checklist identified a specific book feature modeled by the researcher or research assistant, and a different specific feature for participants to practice. Student success had to be confirmed for them to move to the next feature. All participants

achieved 100% accuracy in both traditional textbook and iPad iBook introductory chapters using this checklist. A sample of the Task Analysis Checklists is located in Appendix J.

**TT & iPad iBook lessons.** Lessons 2 and 4-8 served as data collection phases of the study. First, students were asked to wear and start the Q Sensor. They started each lesson with a 2- to 3-minute priming activity using the FRAME Routine, as described in the previous section. Electrodermal activity research has suggested that a priming activity while wearing the Q Sensor helps to establish a baseline measure of EDA levels (Poh et al., 2010). Guided by the researcher or research assistant, students recalled book features and identified the features in the book during this time.

Students were then asked to read the chapter at their own pace as they commonly would in the classroom or for homework. Using the book features, they could note important information, highlight or take notes on notebook paper, watch videos, listen to audio clips, review with practice questions, and, ultimately, read the textbook. The classroom was quiet during this time, distractions such as announcements were kept at a minimum, and no more than four students were engaged in the task at one time. This activity took an average of 20 minutes.

Once students had read and reviewed a book chapter, they were asked to complete the summative book chapter reading comprehension test. Using a printed quiz, extra scratch paper, and a pencil, participants completed multiple-choice, short-answer, and matching exercises ranging from 13 to 18 questions. This activity took an average of 10 minutes. Finally, they completed a measure unique to their lesson and cohort (e.g., satisfaction survey, NASA-TLX). In total, lessons lasted no more than 60 minutes each.

## **Research Design and Analysis**

The study employed a mixed-methods experimental counterbalanced design to compare the effects of an iPad iBook vs. a traditional textbook on reading comprehension, electrodermal activity, and engagement for students with disabilities. Using a repeated measures design and independent *t*-tests, differences in reading comprehension scores, EDA levels, GSES scores, NASA-TLX scores, and student satisfaction were found. Two participant interviews, pre- and post-intervention, were transcribed and coded until themes emerged.

## CHAPTER IV

### RESULTS

This chapter reports the results from an intervention study investigating the effects of an iPad iBook on reading comprehension, electrodermal activity, and engagement for adolescents with disabilities. Twenty-two middle school students with disabilities were randomly assigned to one of two cohorts. Cohorts alternated book treatments across six science chapters. They learned book features that were designed to aid students in finding important information in a traditional textbook and an iPad iBook, and alternated between each book type across six chapters in a middle school science text. In total, students read three chapters using a traditional textbook – and three chapters using an iPad iBook. A repeated-measures design was used, and quantitative and qualitative data, including surveys, were collected for reading comprehension scores, electrodermal activity, cognitive load, and participant satisfaction.

#### **Quantitative Results**

This section reports the findings of the repeated-measures analysis of reading comprehension scores and electrodermal activity (EDA). Additionally, findings from independent samples *t*-tests for the General Self-Efficacy Scale (GSES; Schwarzer & Jerusalem, 1981), NASA Task Load Index (TLX; Hart & Staveland, 1988), and Student Satisfaction Survey are reported. All results were interpreted at  $p < 0.05$  levels, the standard level for statistically significant research results (Fisher, 1925).

**Reading comprehension test results.** This section addresses the first research question: Is there a difference in the reading comprehension scores of students with disabilities when using traditional textbooks compared to iPad iBooks (See Chapter II, page 42)? End-of-chapter tests were used to measure reading comprehension across six science chapters. Each participant

completed three tests after using a TT textbook, and three different tests after using an iPad iBook. Test formats consisted of multiple choice, matching, and short essay questions, varying in length from a total of 13 to 18 questions. Students completed a test immediately after reading a book chapter, for a total of 66 traditional textbook test data points (i.e., three tests per student) and 66 iPad iBook test data points (i.e., three tests per student).

Since each student's book treatment test score was not an independent observation, it was necessary to combine each student's book treatment test scores. Effectively, each student's three traditional textbook scores were averaged together, and their three iPad iBook scores were also averaged together. Thus, each participant contributed two reading comprehension scores—one traditional textbook score and one iPad iBook score—which resulted in 22 reading comprehension test scores for each book treatment.

A repeated-measures analysis was conducted to compare the effects of book type on reading comprehension scores. Also referred to as a two-tailed paired samples *t*-test, the analysis was conducted to compare reading comprehension scores in the TT textbook and the iPad iBook conditions.

Results indicated no statistically significant difference in comprehension scores for traditional textbook ( $M = 70.09$ ,  $SD = 18.61$ ) and iPad iBooks ( $M = 68.5$ ,  $SD = 17.45$ ) conditions;  $t(21) = .713$ ,  $p = .484$ . Thus, researcher failed to reject the null hypothesis that there was no difference in comprehension scores by book type. Further, Cohen's standardized effect size index ( $d = .088$ ) suggested a very low practical significance. Based on these results, therefore, the difference between reading comprehension score means was likely due to chance and not book treatment. Table 6 represents descriptive statistics from this analysis.



Table 6

*Repeated Measures Means and Standard Deviations for Reading Comprehension*

Source	<i>M</i>	<i>SD</i>
TT	70.09	18.61
iPad iBook	68.50	17.45

**Electrodermal activity (EDA) results.** This section addresses the second research question: Is there a difference in the electrodermal activity (EDA) levels of students with disabilities when using traditional textbooks compared to iPad iBooks (see Chapter II, page 42)? Electrodermal activity was measured using the Q-Sensor, a wearable watch-like device developed by Affectiva (see pages 32 – 35 for a description of this device). The Q-Sensor measures skin conductance, a measure of physiological arousal. Arousal levels may change due to changing emotive states or a change in cognitive load.

To measure EDA, participants attached the Q-Sensor to their wrists prior to reading a book chapter and removed it after reading. Video analysis was used to determine the exact starting and ending points for data analysis of EDA levels. A priming activity lasting 2-3 minutes following the Teacher Protocol for Instruction was used (see Appendix I). A priming or orienting activity is recommended when using the device to help the device establish a baseline EDA level (Braithwaite, Watson, Jones, & Rowe, 2013; Critchley, Elliott, Mathias, & Dolan, 2000; Poh, Swenson, & Picard, 2010). For purposes of this study, after attaching the Q-Sensor to their wrist, students were guided to review book features for 2-5 minutes, which served as the baseline establishing activity.

EDA mean levels were determined for each chapter across both book treatments for all participants. Therefore, the total number of EDA mean levels collected was 66 for traditional textbook data points (i.e., three tests per student) and 66 for iPad iBook data points (i.e., three

tests per student). EDA mean levels were calculated and averaged using the same method as for the reading comprehension scores, resulting in 22 observable EDA mean levels for each book treatment.

A repeated-measures analysis was conducted to compare the effects of book type on EDA mean levels. The analysis was conducted to compare EDA mean levels in the TT textbook and the iPad iBook conditions. Results showed no statistically significant difference in EDA mean levels for traditional textbook ( $M = .746, SD = 1.33$ ) and iPad iBooks ( $M = .489, SD = .548$ ) conditions;  $t(21) = 1.134, p = .270$ . Thus, the researcher failed to reject the null hypothesis that there was no difference in EDA mean levels by book type. Further, Cohen’s standardized effect size index ( $d = .253$ ) suggested a small practical significance. Therefore, based on these results, the difference between EDA mean levels was likely due to chance and not book treatment. Table 7 represents descriptive statistics from this analysis.

Table 7

*Repeated Measures Means and Standard Deviations for EDA*

Source	<i>M</i>	<i>SD</i>
TT	.746	1.33
iPad iBook	.489	.548

***Reading comprehension and EDA correlation results.*** Two bivariate correlations were computed to assess the relationships between book treatment and comprehension score and EDA mean levels. In the first analysis, between traditional textbook comprehension scores and EDA mean levels, there was a statistically significant negative correlation between the two variables;  $r = -.423, N = 22, p = .05$ . Overall, as traditional textbook comprehension scores increased, EDA mean levels decreased. In the second analysis, between iPad iBook comprehension scores and EDA mean levels, there was no statistically significant correlation between the two variables;  $r =$

-.298,  $N = 22$ ,  $p = .177$ . Therefore, changes in comprehension scores did not significantly relate to changes in EDA mean levels. Table 8 represents descriptive statistics from this analysis.

Table 8

*Correlations for Book Type*

	TT EDA	iPad iBook EDA
TT Comprehension	-.423*	---
iPad iBook Comprehension	---	-.298

\*  $p = 0.05$  level.

**General Self-Efficacy Scale (GSES) results.** The General Self-Efficacy Scale (GSES) was used to measure the perceived self-efficacy and coping abilities across multiple demands (see Appendix E). All 22 students completed the survey at the beginning of the study. The scale consists of 10 items scored on a 4-point Likert scale ranging from “Not at all true” (“1”) to “Exactly true” (“4”), and summed to a maximum score of 40. An independent samples  $t$ -test was conducted to measure the mean differences in overall self-efficacy scores between participants with and without a specific learning disability.

No statistically significant difference was found in the GSES overall score,  $t(20) = -1.89$ ,  $p = .074$ , for students without a specific learning disability ( $N = 9$ ;  $M = 28.00$ ,  $SD = 4.24$ ) vs. students with a specific learning disability ( $N = 13$ ;  $M = 31.31$ ,  $SD = 3.90$ ).

**NASA Task Load Index (TLX) results.** This section addresses the third research question: Is there a difference in the amount of cognitive load of students with disabilities when using traditional textbooks compared to iPad iBooks (see Chapter II, page 42)? The NASA Task Load Index (TLX) was used to measure the extent to which participants’ cognitive load differed between book type (see Appendix F). Students completed the survey immediately following

three randomly chosen reading comprehension tests; however, one participant did not complete the measure. Thus, the participation rate was 98.48% ( $N = 65$ ).

The survey consists of six questions each rated on a 0 to 100 scale from Low/High or Poor/Good. A weighting procedure provided by NASA was used to combine the subscales into one global score of cognitive load. Mean and standard deviation scores were obtained to determine the feasibility and palpability of the intervention. An independent samples  $t$ -test was conducted for each of the six questions and the overall score to compare workload mean differences for TT (i.e., the traditional textbook) and the iPad iBook. Results of means and standard deviations for both book types are reported in Table 9, and  $t$ -test results are discussed below.

Table 9

*Means and Standard Deviations for NASA-TLX*

How satisfied are you that:	Book Type	$M$	$SD$
Q1: Mental demand – How mentally demanding was the task?	TT	37.88	23.37
	iPad	45.16	22.68
Q2: Physical demand – How physically demanding was the task?	TT	24.09	16.32
	iPad	21.78	16.91
Q3: Temporal demand – How hurried or rushed was the pace of the task?	TT	26.70	22.96
	iPad	26.31	18.91
Q4: Performance – How successful were you in accomplishing what you were asked to do?	TT	29.18	18.54
	iPad	23.22	17.23
Q5: Effort – How hard did you have to work to accomplish your level of performance?	TT	47.85	25.16
	iPad	47.16	22.35
Q6: Frustration – How insecure, discouraged, irritated, stressed, or annoyed were you?	TT	21.88	24.62
	iPad	18.25	19.70
Overall workload score	TT	31.26	12.87
	iPad	30.21	14.71

*Note.* TT = traditional textbook.

For Question 1, there was no statistically significant difference in the scores for TT ( $M = 37.88$ ,  $SD = 23.37$ ) and iPad iBook ( $M = 45.16$ ,  $SD = 22.68$ ) conditions;  $t(63) = -1.27$ ,  $p = .208$ .

These results suggest that there were no significant mental demand differences whether using the traditional textbook or iPad iBook.

For Question 2, there was no statistically significant difference in the scores for TT ( $M = 24.09$ ,  $SD = 16.32$ ) and iPad iBook ( $M = 21.78$ ,  $SD = 16.91$ ) conditions;  $t(63) = .560$ ,  $p = .577$ .

These results suggest that there were no significant physical demand differences whether using the traditional textbook or iPad iBook.

For Question 3, there was no statistically significant difference in the scores for TT ( $M = 26.70$ ,  $SD = 22.96$ ) and iPad iBook ( $M = 26.31$ ,  $SD = 18.91$ ) conditions;  $t(63) = .074$ ,  $p = .942$ .

These results suggest that there were no significant temporal demand differences whether using the traditional textbook or iPad iBook.

For Question 4, there was no statistically significant difference in the scores for TT ( $M = 29.18$ ,  $SD = 18.54$ ) and iPad iBook ( $M = 23.22$ ,  $SD = 17.23$ ) conditions;  $t(63) = 1.34$ ,  $p = .184$ .

These results suggest that there were no significant perceived performance differences whether using the traditional textbook or iPad iBook.

For Question 5, there was no statistically significant difference in the scores for TT ( $M = 47.85$ ,  $SD = 25.16$ ) and iPad iBook ( $M = 47.16$ ,  $SD = 23.35$ ) conditions;  $t(63) = .117$ ,  $p = .907$ .

These results suggest that there were no significant perceived effort differences whether using the traditional textbook or iPad iBook.

For Question 6, there was no statistically significant difference in the scores for TT ( $M = 21.88$ ,  $SD = 24.62$ ) and iPad iBook ( $M = 18.25$ ,  $SD = 19.70$ ) conditions;  $t(63) = .655$ ,  $p = .515$ .

These results suggest that there were no significant frustration differences whether using the traditional textbook or iPad iBook.

Finally, for overall workload scores, there was no statistically significant difference in the scores for TT ( $M = 31.26$ ,  $SD = 12.87$ ) and iPad iBook ( $M = 30.21$ ,  $SD = 14.71$ ) conditions;  $t(63) = .278$ ,  $p = .782$ . These results suggest that there were no significant overall workload differences whether using the traditional textbook or iPad iBook.

**Student Satisfaction Surveys results.** This section addresses the fourth research question: To what extent are students with disabilities who are taught features of traditional textbooks and iPad iBooks satisfied with each format (see Chapter II, page 42)? The Textbook Student Satisfaction Survey and iPad Student Satisfaction Survey were used to measure the extent to which participants were satisfied with either book type (see Appendix G). Students completed the surveys immediately following three randomly chosen reading comprehension tests; therefore, the participation rate was 100% ( $N = 66$ ). The survey consisted of seven questions rated on a 6-point Likert scale ranging from “Completely dissatisfied” (“1”) to “Completely satisfied” (“6”). Mean and standard deviation scores were obtained to determine the feasibility and palpability of the intervention. An independent samples  $t$ -test was conducted to measure the mean differences for each of the seven questions and the overall score to compare satisfaction for TT (i.e., the traditional textbook) and the iPad iBook. Results of means and standard deviations for both book types are reported in Table 10, and  $t$ -test results are discussed below.

Table 10

*Means and Standard Deviations for Student Satisfaction Surveys*

How satisfied are you that:	Book Type	Mean	SD
Q1: The [book type] helped you understand the chapter?	TT	4.09	0.91
	iPad	4.91	0.84
Q2: It was easy to use the [book type]?	TT	4.55	1.06
	iPad	5.27	0.80
Q3: You can find the main idea of the chapter?	TT	4.45	1.37
	iPad	5.09	1.01
Q4: You can paraphrase the chapter?	TT	4.03	1.24
	iPad	4.67	1.16
Q5: You can use [book type] for other classes or outside of school?	TT	4.06	1.64
	iPad	5.24	0.97
Q6: You will be able to use [book type] on your own?	TT	4.58	1.48
	iPad	5.15	1.00
Q7: Overall, how satisfied are you with [book type]?	TT	4.51	1.06
	iPad	5.61	0.66
Overall score	TT	30.27	6.36
	iPad	35.94	4.19

*Note.* TT = traditional textbook.

For Question 1, there was a statistically significant difference in the scores for TT ( $M = 4.09$ ,  $SD = 0.91$ ) and iPad iBook ( $M = 4.91$ ,  $SD = 0.84$ ) conditions;  $t(64) = -3.78$ ,  $p = .000$ . These results suggest that participants were more satisfied using the iPad to understand the chapter than the traditional textbook.

For Question 2, there was a statistically significant difference in the scores for TT ( $M = 4.55$ ,  $SD = 1.06$ ) and iPad iBook ( $M = 5.27$ ,  $SD = 0.80$ ) conditions;  $t(64) = -3.14$ ,  $p = .003$ . These results suggest that participants were more satisfied with the iPad's ease of use than with the traditional textbook.

For Question 3, there was a statistically significant difference in the scores for TT ( $M = 4.45$ ,  $SD = 1.37$ ) and iPad iBook ( $M = 5.09$ ,  $SD = 1.01$ ) conditions;  $t(64) = -2.15$ ,  $p = .036$ . These results suggest that participants were more satisfied with the success of finding the main idea using the iPad iBook than the traditional textbook.

For Question 4, there was a statistically significant difference in the scores for TT ( $M = 4.03$ ,  $SD = 1.24$ ) and iPad iBook ( $M = 4.67$ ,  $SD = 1.16$ ) conditions;  $t(64) = -2.15$ ,  $p = .035$ . These results suggest that participants were more satisfied with the success of paraphrasing the chapter using the iPad iBook than the traditional textbook.

For Question 5, there was a statistically significant difference in the scores for TT ( $M = 4.06$ ,  $SD = 1.64$ ) and iPad iBook ( $M = 5.24$ ,  $SD = 0.97$ ) conditions;  $t(64) = -3.57$ ,  $p = .001$ . These results suggest that participants were more satisfied with using the iPad iBook for other classes or outside of school than the traditional textbook.

For Question 6, there was a not a statistically significant difference in the scores for TT ( $M = 4.58$ ,  $SD = 1.48$ ) and iPad iBook ( $M = 5.15$ ,  $SD = 1.00$ ) conditions;  $t(64) = -1.85$ ,  $p = .069$ . These results suggest that participants were not significantly more satisfied using the iPad iBook or the traditional textbook on their own.

For Question 7, there was a statistically significant difference in the scores for TT ( $M = 4.51$ ,  $SD = 1.06$ ) and iPad iBook ( $M = 5.61$ ,  $SD = 0.66$ ) conditions;  $t(64) = -5.01$ ,  $p = .000$ . These results suggest that participants were more satisfied overall with the iPad iBook than with the traditional textbook.

Finally, for total satisfaction scores, a significant difference were found between the scores for TT ( $M = 30.27$ ,  $SD = 6.36$ ) and iPad iBook ( $M = 35.94$ ,  $SD = 4.19$ ) conditions;  $t(64) =$



-4.28,  $p = .000$ . These results suggest that participants were more satisfied overall with the iPad iBook than with the traditional textbook.

### **Qualitative and Survey Results**

This section reports the findings for two semi-structured interviews (see Appendix H) and addresses the fifth and final research question: What do students with disabilities report as being the most (least) helpful features and how would they prefer to use the traditional textbook and iPad iBook (see Chapter II, page 42)?

The first interview took place at the beginning of the study, and the second interview took place upon conclusion of the study. Two students were unable to complete one interview each, resulting in a participation rate of 95.54% ( $N = 42$ ). Forty-two interviews (two each of 22 students; two students missed an interview) were transcribed, codified, and grouped into distinct categories using a naturalistic inquiry approach (Lincoln & Guba, 1985). Due to students being interviewed twice, and some questions overlapping, total data do not total 21 unique responses. Students were able to consider and respond to the following questions multiple times. Emergent themes were organized and are summarized below.

**Which book type helps you learn and comprehend better?** Students were asked to identify which book type would result in more learning and higher reading comprehension scores. A total of 42 responses were given. Eight responses favored the TT traditional textbook, 27 favored the iPad iBook, and 7 favored both book types equally (see Figure 2).

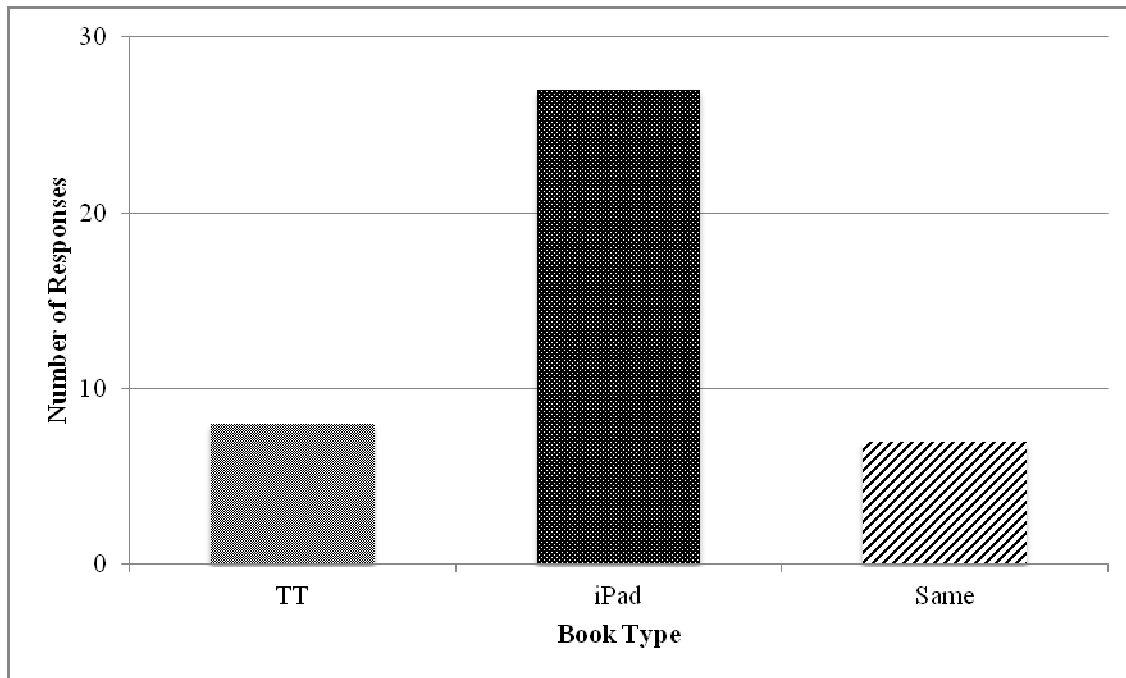


Figure 2

*Which book type helps you learn and comprehend better?*

**In what classes do you prefer to use [book type]?** Students were asked to identify the specific classes in which they would prefer to use each book type. Of note, students were free to answer as much or as little of this question as they wished; thus, more responses were recorded than the number of participants interviewed. “Content” refers to mathematics, science, social studies, or other content-area classes. “English Language Arts” refers to English, reading, literature, writing, or other language classes. “Other” refers to homeroom, study hall, or free choice time.

For “Content,” six responses favored the TT textbook and 17 responses favored the iPad iBook. For “English Language Arts,” four responses favored the TT textbook and 15 responses favored the iPad iBook. Finally, for “Other,” three responses favored the TT textbook and five responses favored the iPad iBook (see Figure 3).

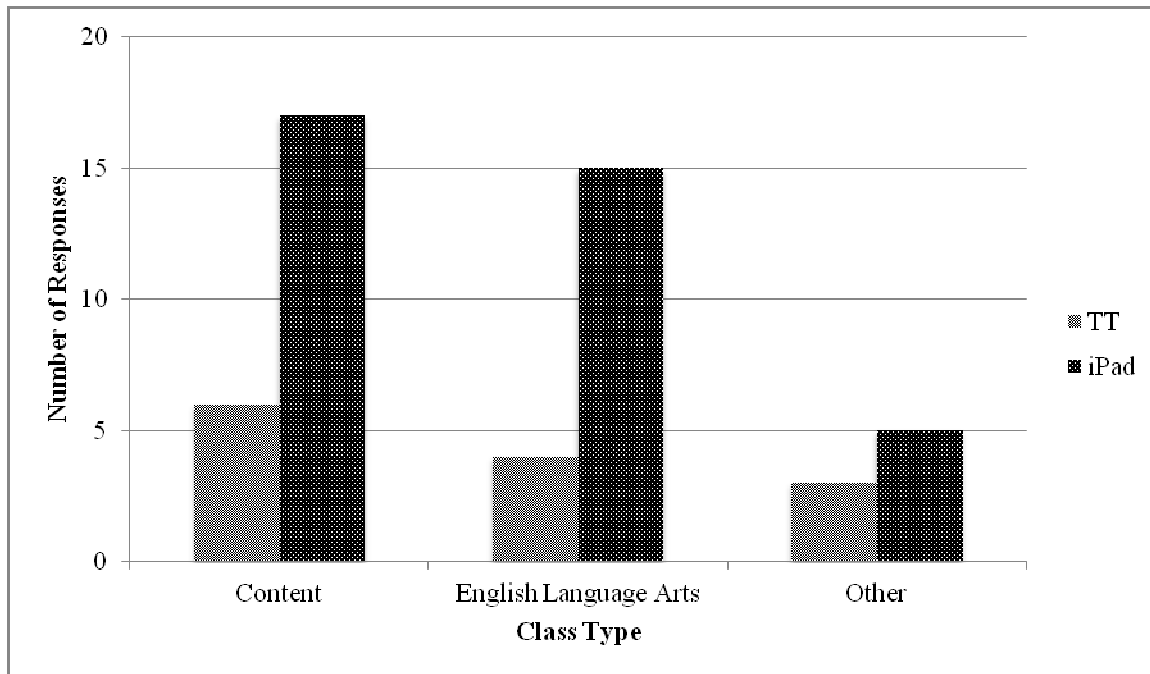


Figure 3

*Which classes do you prefer to use [book type]?*

**Which features were most useful?** Students were asked to identify what specific features were most helpful to them or that they used the most for each book type. Of note, students were free to respond with as many or as few features as they wished; thus, more responses were recorded than the number of participants interviewed. A total of 72 individual responses for the TT textbook and 80 individual responses for the iPad iBook were given. (See Chapter III, pages 49 to 51, for a detailed description of each book feature.) Of note, the TT textbook book type did not have the capability to provide the following features: “Video,” “Interactivity,” and “Audio.” Students identified “Highlighting & Note-taking” ( $n = 20$ ), “Text Clues” ( $n = 15$ ), and “Pictures” ( $n = 12$ ) as the three most useful TT textbook features. By comparison, students identified “Video” ( $n = 17$ ), “Interactivity” ( $n = 15$ ), and “Audio” ( $n = 15$ ) as the three most useful iPad iBook features (see Figure 4).

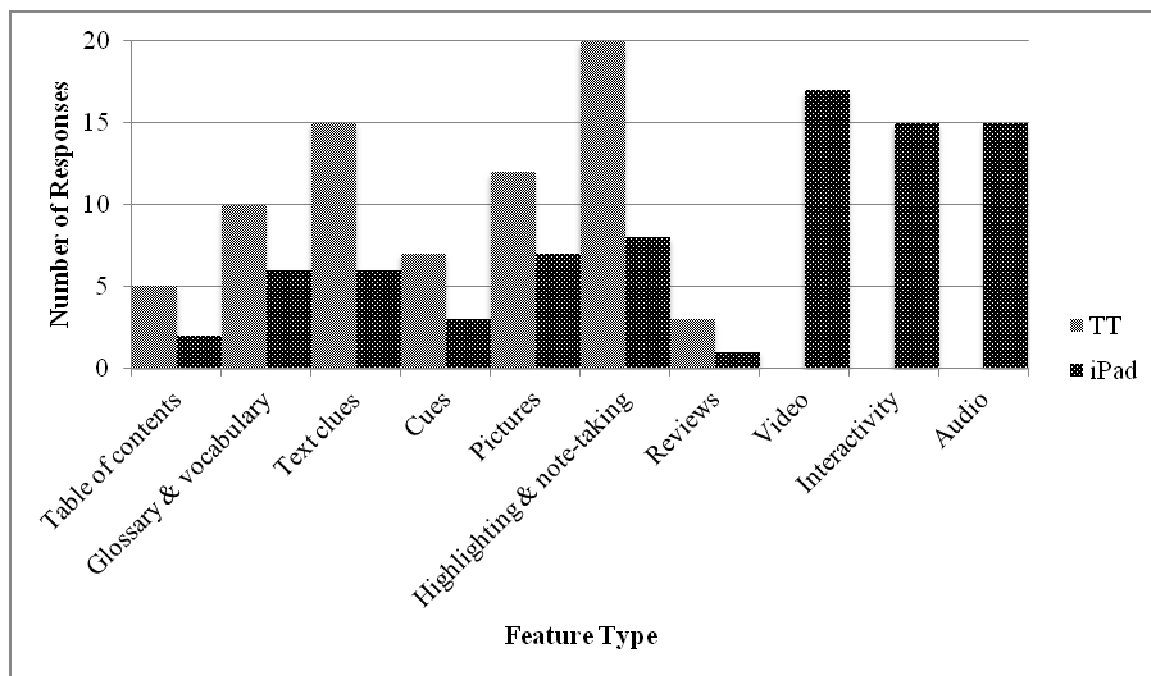


Figure 4

*Which features were most useful?*

**Which features were least useful?** Students were asked to identify which specific features were the least helpful or that they used the least for each book type. Identical to the previous question, students were free to respond with as many or as few features as they wished; thus, more responses were recorded than the number of participants interviewed. Forty-five individual responses for the TT traditional textbook and 45 individual responses for the iPad iBook were given. (See Chapter III, pages 49 to 51, for a detailed description of each book feature.) Of note, the TT textbook book type did not have the capability to provide the following features: “Video,” “Interactivity,” and “Audio.” Students identified “Reviews” ( $n = 11$ ), “Pictures” ( $n = 8$ ), and “Cues” ( $n = 7$ ) as the three least useful TT textbook features. By comparison, students identified “Glossary & Vocabulary” ( $n = 8$ ), “Reviews” ( $n = 7$ ), and “Pictures” ( $n = 6$ ) as the three least useful iPad iBook features (see Figure 5).

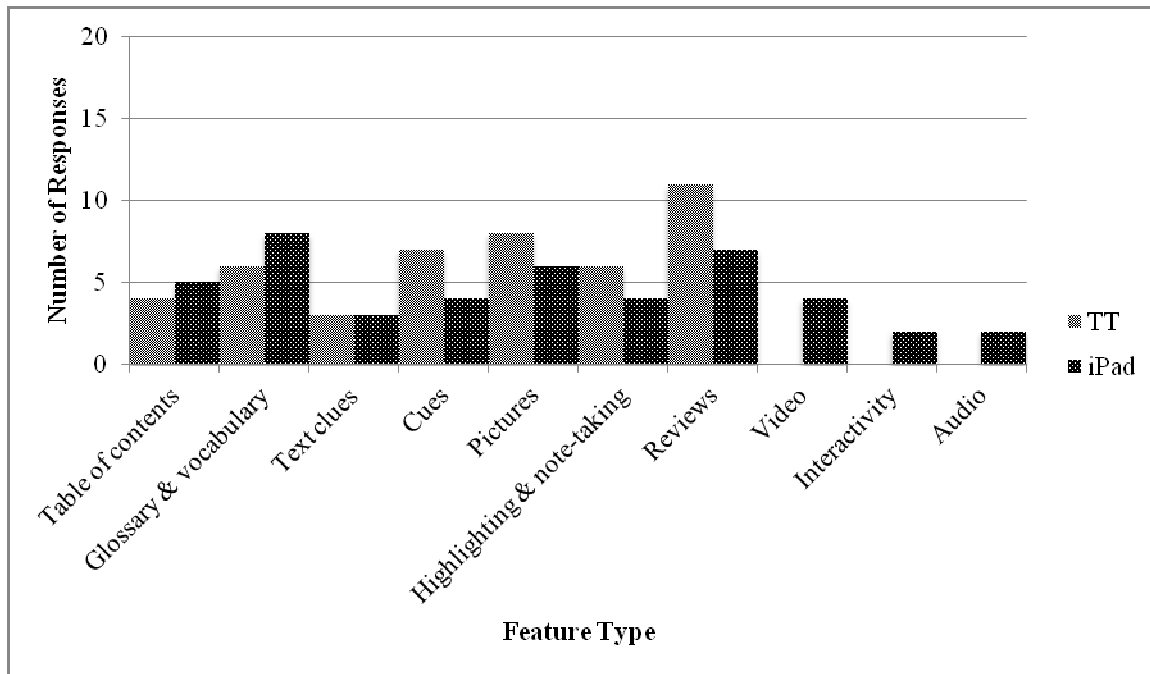


Figure 5

*Which features were least useful?*

**Emergent theme #1: Accessibility and instructional design of iPad iBooks.** When asked about their experiences using each book type, most students emphasized accessibility and instructional design. Specifically, student responses categorized under this emergent theme noted how books leverage accessibility features to make learning easier. As an example, students noted that the iPad provided accessibility features such as enlargement of text: “Sometimes the lettering can’t be as big as it can be on the iPad, so it’s easier to read on the iPad” and “Sometimes the words are too small, like the font or it can get to be too much on one page.” Another student mentioned the iPad’s ability to access different learning preferences: “Well, if you’re a visual or vocal learner, that could be a disadvantage to reading a normal book. I think the iPad helps more.” Considering that all students in this study were diagnosed with a disability, many were familiar with identifying important accessibility features.

Related to accessibility, students also commented on how learning experiences can be made more meaningful through individualized, thoughtful instructional design. Specifically, students commented on how the iPad offers “multiple sources” that are more “interesting to look at” and “not as bland as a textbook.” One student succinctly summarized this experience: “When you read on an iPad, it’s kind of like being in a new universe. ‘This is new, it’s different.’ But it’s just so much more different because it’s more hands-on than with a textbook. With a textbook, you just turn the page and read it.” iPad iBook features are central to this “universe,” as noted by another participant: “Glossary, videos, and the interactivity and audio. And those are what technology can bring [when using the iPad iBook].” For these reasons, it appeared that students were aware of the features used in the iPad iBook that increased accessibility and individualized instructional design, and were able to distinctly identify them.

**Emergent theme #2: Cognitive load.** Another emergent theme from the semi-structured interviews was students’ description of how learning differed among each book type. Specifically, students addressed how the effort required to learn from each book type differed. One student said: “The paper textbook is more just you’re reading a line, reading a line, reading a line. But with the iPad, it’s not as boring, you’re not just reading.” Furthering this notion of the iPad iBook providing a more engaging environment, another student added: “iPads you can watch videos on there. It’s really not like ... it’s just way different than just sitting there and reading a book. You’re actually using something and knowing what to do other than just sitting there and doing nothing, really.” A third student said, “It’s a little bit more hands-on rather than just sitting there and reading a book because it seems more fun. You can actually click on something and maybe it’ll show a video or other things.” Distinction between high cognitive

load and cognitive boredom was important to students when evaluating their learning experiences.

In discussing the learning experiences of each book, students noted how the iPad iBook was easier to learn from. For instance, “If I would have read on a textbook, I would probably read the line over about 25 times until it’s time to finish. But on iBooks it makes it much more entertaining with the videos and the audio and being able to do all that.” Thus, it appeared that it was not just the entertainment factor of the iPad that engaged students more; it was also the device’s ability to “take most of the important information and shorten it down.” Students identified that the iPad iBook was more engaging and hands-on and also that it was a more comfortable experience: “On the iPad, to me it feels more comfortable because it’s sort of in my element ... I feel more comfortable in the iPad.” One particular comment highlighted how the iPad iBook supported differentiated learning, too: “All the information is in small, little chapters and there’s multiple ways to get information.”

Finally, a small number of students noted that while the iPad iBook may have been more engaging or accessible, the TT textbook was better for learning. “I feel more comfortable in the iPad, but I know for a fact that it’s better to use the textbook!” Cognitive load may work in the reverse direction too, this student noted: “I would say I do better on a book [traditional textbook]. You’re thinking more about how cool an iPad is more than you’re thinking about reading on a textbook.” Another commented, “I liked it [the traditional textbook] because it’s a lot easier to read. And that’s my opinion, but since we are getting into that era where everything is computerized, I’m going to have to get into the iPad stuff, I can already tell now.” Finally, one student was able to differentiate the value of each book type: “I can read easier on the iPad iBook but remember better on a textbook. I’m just more used to it on the textbook.”

## **Fidelity of Implementation**

**Fidelity Checklist for iPad iBooks Instructional Design Rules.** The fidelity checklist (see Appendix B) provided the researcher and the research assistant with steps to follow in identifying specific features required for each chapter within the iPad iBook (i.e., two review opportunities, one video segment, two interactive widgets, and one audio segment). This confirmation demonstrated that each chapter was consistent in providing an equal number of features. Interrater reliability confirmed that the application of these rules for instructional design was 100%.



## CHAPTER V

### DISCUSSION

The purpose of this mixed-methods intervention study was to compare the effects of a traditional textbook and an iPad iBook. Specifically, the study examined the differences between two book treatment types by assessing (a) reading comprehension test scores, (b) electrodermal activity (EDA), (c) cognitive load scores on the NASA-TLX (Hart & Staveland, 1988), and (d) student satisfaction surveys. In addition, two semi-structured interviews were used to gather qualitative data, including surveys, on students' perceptions of which (a) book type supported learning and comprehension better, (b) specific classes in which students would prefer to use each book type, and (c) features were most and least useful. Results from the repeated-measures and independent samples *t*-tests analyses, when triangulated with the qualitative data, highlighted several trends. The findings, while providing a somewhat inconsistent portrait of the utility of either book type when interpreted independently, hold promise for future research endeavors when integrated.

Overall, reading comprehension scores, EDA mean levels, and NASA-TLX scores did not differ significantly. However, satisfaction scores differed significantly on seven of the eight questions, indicating a strong student preference for classroom use of the iPad iBook. In addition, qualitative and survey data yielded results favoring iPad iBooks as (a) as more helpful in supporting learning and comprehension; (b) the preferred textbook format in content, English Language Arts, and other classes; and (c) having features that were noted most frequently as most useful. Because some struggling readers evidence a lack of motivation to engage in reading activities (Durlak et al., 2011; Zins et al., 2007), students' relatively strong preferences for the iPad iBook format may underscore its value as a potential intervention for enhancing reading

comprehension of adolescents with specific learning disabilities compared to the TT (traditional textbook).

## **Conclusions**

After systematically teaching students to use book features to comprehend complex expository texts, several conclusions were drawn. First, using a repeated-measures design, mean scores for the TT book ( $M = 70.09$ ) and the iPad iBook ( $M = 68.50$ ) differed but yielded no statistically significant differences in reading comprehension scores. Despite the difference in comprehension scores, this value has no apparent educational significance.

Second, results from both emotional measures and cognitive load measures did not yield significant differences. The Q Sensor was used to measure affective physiological responses to textbook environments. Using a repeated-measures design, EDA mean levels for the TT textbook ( $M = .746$ ) and the iPad iBook ( $M = .489$ ) differed but yielded no statistically significant differences. Because current research suggests that arousal responses may be due to changes in emotive state, attention, or cognitive load, it is difficult to interpret EDA mean levels independently (Critchley, 2002; Dawson, Schell, & Filion, 2007; Fowles, 1980; Malmivuo & Plonsey, 1995). Similarly, no significant differences were found between book type on the cognitive load NASA-TLX metric. On average, EDA mean levels were higher for the TT book type, and five of the seven NASA-TLX cognitive load questions were also higher for the TT book type.

Third, the results from the student satisfaction survey are promising indicators of the feasibility and palatability of the iPad iBook intervention. Even though 95% of participants had never used an iPad iBook prior to the study, it was overwhelmingly the preferred book type. More specifically, all eight satisfaction questions generated higher means and lower standard

deviation variances, with seven questions yielding statistically significant higher scores for the iPad iBook than the traditional textbook.

Fourth, qualitative and survey data reinforced the satisfaction survey findings. Specifically, three categorical questions from the semi-structured interviews yielded responses heavily favoring the iPad iBook as the preferred textbook type for classroom use. When asked to identify which book type facilitated more learning and comprehension, 27 students preferred the iPad iBook compared to 8 students preferring TT, a ratio greater than 3:1. When asked to identify which book type students preferred for Content, English Language Arts, and Other classes, the iPad iBook was preferred by ratios of nearly 3:1, 4:1, and 2:1, respectively. Finally, the three features unique to the iPad iBook (i.e., video, interactivity, audio) were widely endorsed as being the most useful.

### **Relationship to Previous Research**

The findings of the current study support previous research by (a) demonstrating that explicit instruction is an effective model for teaching adolescents with specific learning disabilities critical book features to facilitate reading comprehension; (b) highlighting that textbook features that leverage accessibility and multiple means of representation are a promising avenue for developing appropriate content for struggling learners; and (c) showing that when students' affective, physiological, and emotional responses to content are considered, students in general enjoy learning.

First, previous studies have found that interventions for struggling adolescent learners, both with and without diagnosed disabilities, benefit from direct and explicit instruction (Archer & Hughes, 2010; Edmonds et al., 2009; Gersten, Fuchs, Williams, & Baker, 2001; Mastropieri Scruggs, & Graetz, 2003; Swanson, 1999; Swanson & Hoskyn, 2001; Vaughn, Gersten, &

Chard, 2000). Specifically, this study's results demonstrated that when students are taught the explicit instruction methodology developed by researchers at the University of Kansas Center for Research on Learning (Boudah, Lenz, Bulgren, Schumaker, & Deshler, 2000; Deshler et al., 2001; Deshler & Schumaker, 1988), they are able to identify and use key book features found in expository texts. This instruction provides a solid foundation addressing the ultimate goal of reading for adolescents: improving reading comprehension. Further research in this area should include teaching practices that follow similar instructional procedures.

Second, it is important to carefully consider the instructional design of a textbook, as well as how to create content that is accessible and manageable for all learners. Instructional design may refer to the layout of content or presentation of material (László, 2006; Mayer, 2009; Němcová, 2012). This includes presenting information that fosters an appropriate level of engagement and attention without cognitively overloading students. Others have referred to this as the structural components of Universal Design for Learning, including multiple means of representation, action and expression, and engagement (Basham, Israel, Graden, Poth, & Winston, 2010; Rose & Meyer, 2000; Smith & Meyen, 2003). Participants in this study were aware of these considerations, and were sensitive to the features within a book that promoted sustained attention and excitement. A strength of the iPad iBook over the traditional textbook, it appears, is its ability to leverage book features that promoted an enhanced learning experience.

Finally, this study builds upon the work of previous studies in several important ways related to physiological inquiry. Contemporary policy efforts (i.e., NCLB, RTTT, CCSS) have focused on comprehensive academic reform, potentially at the expense of other student factors like social or emotional factors (Ravitch, 2013; Tough, 2012). For instance, few studies were identified that used the Q Sensor as a tool to measure affective response to improving academic

outcomes for adolescents with disabilities (Afectiva, Inc., 2013; Hill, Berthoz, & Frith, 2004; Picard, 2013; Poh, Swenson, & Picard, 2010). However, research suggests that high-achieving students are engaged much more than their low-achieving peers (Frederick, 1977; Rock, 2005) and that the prevention of student disengagement can lead to higher graduation rates (Balfanz, Herzog, & Mac Iver, 2007). For these reasons, it is valuable to consider not only the academic outcomes of an intervention but also the socio-emotional feedback of students who are disconnected and accustomed to engaging and attending less than their peers.

This study attempted to measure affective and socio-emotional responses to an intervention as much as academic outcomes. For hypothesized reasons described in the Limitations section below, no statistically significant differences were found in measures of reading, EDA, or cognitive load; however, findings did suggest a trend of iPad iBook preference across four of the five quantitative and qualitative measures. For these reasons, the present study provides a valuable contribution to the field.

### **Limitations**

This study has several limitations, which include (a) reading comprehension measures, (b) EDA analysis, and (c) study sample.

**Reading comprehension measures used.** End-of-chapter tests developed by the textbook publisher were used. Even though comprehension questions were related to the content, minimal, non-significant differences were found between book types. A test consisting of 13-18 comprehension questions that students have to answer after reading a chapter for 20-30 minutes may not fully depict all relevant content. Alternatives to measuring student learning of the text should be considered for future research. For example, fluency proxies, more multiple-choice questions, or maze procedures may serve as better measures of comprehension when evaluating

textbook treatments (Espin, Wallace, Lembke, Campbell, & Long, 2010; Fletcher et al., 2001; Fletcher & Vaughn, 2009; Rasinski et al., 2005; Snyder et al., 2001).

It has been suggested that rapid word recognition, commonly referred to as fluency, is a useful predictor of reading comprehension (Barth, Catts, & Anthony, 2009; Cutting & Scarborough, 2006; Rasinski et al., 2005). Notably, Rasinski and colleagues (2005) contended that when significant cognitive load is devoted to low-level fluency, such as the decoding of basic words, cognitive energy is “taken away from the more important task of comprehending the text. Hence, comprehension is negatively affected by a reader’s lack of fluency” (p. 22). Conversely, if less cognitive load is spent recognizing, decoding, and fluently reading a text, more resources are available to tend to the ultimate goal of reading: comprehension. Studies investigating the correlations and variances suggest that measures of fluency may reliably assess and serve as comprehension measures (Barth et al., 2009; Cutting & Scarborough, 2006).

If fluency measures do, in fact, measure a significant portion of reading comprehension skills, it may be worthwhile to conduct a study of iPad iBooks using responsiveness to curriculum-based measurements (CBM). CBMs typically contain short text passages read over a length of 1 or 2 minutes, and identify the percentage of words correctly read per minute (Fletcher et al., 2001; Fletcher & Vaughn, 2009). These measures are less demanding and provide a larger source of data than a lone end-of-chapter test. If a study were conducted using a content-area text with appropriate fluency measures at the end of each chapter section rather than each chapter, perhaps the measures would be more responsive and more sensitive to changes in the iPad format. This, in turn, would allow researchers to more accurately measure what aspects of the iPad iBook affected fluency or comprehension changes, such as a unique video widget or the glossary or vocabulary words. These kinds of measures do exist; for example, the Test of Silent

Contextual Reading Fluency (TOSRF; Hammill, Wiederholt, & Allen, 2006) is significantly correlated with measures of reading comprehension and has demonstrated some validity.

However, several researchers have suggested the TOSRF is not a robust measure of or a proxy for comprehension (Bell, McCallum, Kirk, Fuller, & McCane-Bowling, 2007; Synder, Caccamise, & Wise, 2005), and recommend not using proximal fluency measures as adequate measures of reading comprehension.

Finally, alternatives to curriculum-based measurements of fluency do exist. For example, multiple-choice questions and maze procedures may hold promise for this type of research. Multiple-choice questions require more content-area text, and may more accurately measure comprehension than other types of questioning (Snyder et al., 2001). Another brief assessment that correlates with reading comprehension, the maze procedure, consists of short text passages in which every seventh word is omitted. For each omission, students are presented with three choices, one of which contains the word necessary to complete the text. This assessment may also serve as a predictor of reading comprehension (Espin, Wallace, Lembke, Campbell, & Long, 2010). Ideally, if a text was developed using a curriculum-based measurement or maze procedure assessment to measure reading comprehension skills at a higher frequency than once per chapter, perhaps we would be better assess the unique features of the iPad iBook.

**EDA data.** It was determined that although baselines were established for each participant, EDA levels would not serve as a function of the baseline change. This type of transformation or normalization can help account for individual differences in EDA levels. Transforming and standardizing the data corrects for inter-individual variance, which can improve validity and reliability of the data set (Boucsein, 2012; Braithwaite, Watson, Jones, & Rowe, 2013; Dawson, Schell, & Fillion, 2007). While many methods are available for doing so, a

common method is to calculate range-corrected scores from a baseline activity, which helps to reduce the effect of external environmental stimuli from affecting EDA levels (Daily, Meyers, Darnell, Roy, & James, 2013). The researcher chose not to conduct this procedure for three reasons. First, participants served as their own controls within this study. By completing three book chapters using each book type, student EDA level baselines were present within each treatment, effectively counterbalancing one another in the repeated-measures design. Second, the intervention did not lend itself to replicating an experience that was identical for each student. Namely, students were free to choose which portion of the book to read, for how long, and what content to focus on. Thus, while experiences were generally the same, student variability within each book chapter was unique. Finally, most studies of the Q Sensor and measures of electrodermal activity through skin conductance responses (SCRs) have traditionally used a more controlled design than the study presented here. Rather than presenting a lone stimulus, students were concurrently exposed to interactive widgets, video, audio, and other book activities. This type of instructional design made it difficult to isolate exactly which stimuli was affecting the EDA levels.

For these reasons, it made logical sense to analyze the EDA data at the mean level. As such, means were determined for each participant immediately following the priming baseline activity until completion of the chapter. Baselines would have allowed for each participant to have a unique EDA resting level, which then could be compared to delta. Furthermore, it is common practice to record the amplitude of each individual response, followed by appropriate time to recover prior to the next SCR (Dawson, Schell, & Filion, 2007). Without an opportunity to recover, subsequent SCRs are largely functions of the primary response (Grings & Schell, 1969). Habituation exposure to repeating stimuli (such as the iPad iBooks' interactive widgets) is



prone to less responsive and lower EDA levels, too (Dawson et al., 2007). Others have suggested that without a similar frequency of opportunities to measure SCR, participant means are not advisable (Braitwaite, Watson, Jones, & Rowe, 2013). However, given the length of each student session—typically a half hour—it was outside the scope of this dissertation study to evaluate 132 individual 30-minute EDA files.

Another significant EDA analysis limitation was an inability to control for many confounding variables. Specifically, environmental factors such as room temperature, lighting, school announcements and interruptions, and time of day are critical factors in understanding and interpreting EDA. All reasonable precautions were taken to control for such variables, including a closed-door quiet classroom with minimal distractions and a systematic routine that promoted a comfortable and engaging learning environment. Other important artifacts affecting EDA levels, such as minimizing coughs, bodily movement, or social interaction were discussed with participants, too. However, some environmental factors could not be reasonably controlled, such as fire drills, schoolwide announcements, and unscheduled interruptions. Finally, the analysis of EDA was limited by participant characteristics. These may have included disability type, age, grade, sex, medication, and IQ. An attempt to control disability type, grade, medication, and IQ was made through use of the repeated-measures design; however, this was a possible limitation in understanding their effects on EDA levels.

**Study sample.** The final limitation of the study relates to study sample and statistical power. The sample of 22 adolescent students was limited in both size and generalizability. All participants were diagnosed with a disability and enrolled at one school. Students with disabilities may respond differently to textbook features and yield different academic and affective responses to a traditional textbook or iPad iBook than students without disabilities.

Furthermore, many of the quantitative data results suffered from a low statistical power. A small statistical power makes the likelihood of observing an effect size lower (Nakagawa, 2004). This suggests that in spite of non-statistically significant converging data sources favoring the iPad iBook, six lessons were not enough to produce statistically significant differences and effects in reading comprehension scores or EDA means.

### **Implications for Future Research**

This study was an initial attempt to examine the effects of an iPad iBook intervention. Additional research is needed to expand upon the findings. First, considering the iPad iBook and iBooks Author software are new technologies, a study design that provides students with additional experiences to use such a book format may allow for a more thorough examination of the intervention. Two one-hour sessions were devoted to an instructional overview of describing, modeling, practicing, and providing feedback into the iPad iBook and how to use it. However, compared to TT textbooks, which students had spent their entire academic careers using, this length of time seems insignificant. Only 1 of the 22 participants reported as ever using an iPad iBook prior to this study. If further research were to be conducted using the iPad iBook, clearly students would benefit from additional practice and exposure to such an intervention.

Second, participants were surprisingly unfamiliar with textbook features. For example, features found in nearly every academic textbook—such as the glossary or table of contents—were entirely new features to many. Large bodies of research exists for teaching adolescents with disabilities how to effectively read a text, find important information, organize critical content, and demonstrate competencies (Deshler et al., 2001; Lenz et al., 1993). However, when it comes to separating the activities of learning to read, reading to learn, and managing the environment of a textbook, it appears that struggling adolescents with disabilities are not adequately taught how

to manage and navigate a content-area text. Further research in this area supports prior efforts (Biancarosa & Snow, 2004; Budiansky, 2001; Bulgren, Schumaker, Deshler, Lenz & Marquis, 2002; Deshler & Hock, 2007; Edmonds et al., 2009; Kesidou & Roseman, 2002; Kulm & Roseman, 1999; RAND Reading Study Group, 2002; Roseman, Kulm, & Shuttleworth, 2001; Swanson & Deshler, 2003; Swanson & Hoskyn, 2001; Vaughn, Gersten, & Chard, 2000) suggesting that strategies or teacher practices include teaching students how to navigate the environment and instructional design of a textbook.

Finally, it is important to highlight the affective experience of reading to learn. Electrodermal activity mean levels, while not statistically significant between book types, were lower when using the iPad iBook and, when triangulated with statistically significant satisfaction scores and qualitative reporting, paint a picture of students generally enjoying their experience with an iPad iBook more than with a traditional textbook. Any future research should consider Mayer's (Mayer, 2002, 2003, 2009; Mayer & Moreno, 2003) cognitive theory of multimedia learning in applying principles of quality instructional design to the creation of a digital textbook. By parsing out individual widgets or features within the iPad iBook, a fuller picture may emerge that accurately describes which features positively affect students' physiological responses to engaged learning.

## **Summary**

The results of this study suggest that the iPad iBook is the favored textbook type when reading, comprehending, and learning from middle school content-area texts. As both a hardware and software mechanism, the Apple iPad has the potential to positively impact academic outcomes for adolescents with disabilities. Furthermore, considering affective socio-emotional responses to an intervention through physiological and satisfaction surveys appears to be a

worthy avenue for further exploration. Students responded favorably to learning about textbook features like text clues and highlighting and note taking, but overwhelmingly favored the iPad iBook-specific widgets like video, interactivity, and audio. However, no significant differences were found on measures of academic outcomes. It is imperative that further research using the iPad iBook carefully considers reading outcomes and methods for addressing this new technology as compared to other book formats. Therefore, this study demonstrates that explicit instruction used to teach adolescents with disabilities how to focus on iPad iBook features is a promising method for finding important information in a textbook. However, more research in this area is needed to best address the unique needs of adolescents with disabilities when reading an iPad iBook for academic purposes.

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**APPENDIX A**  
**FRAME Graphic Organizer**  
**and**  
**Features of Books**



# The FRAME Routine

Key Topic

\_\_\_\_\_ is about...

Main idea

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
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Main idea

\_\_\_\_\_  
\_\_\_\_\_  
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\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

So What? (What's important to understand about this?)

\_\_\_\_\_

## Features of books

	<b>Textbook</b>	<b>iPad</b>
<b>1</b>	Table of contents	Table of contents
<b>2</b>	Glossary & vocabulary	Glossary & vocabulary
<b>3</b>	Text clues (bold, italic, underline, font, color, size)	Text clues (bold, italic, underline, font, color, size)
<b>4</b>	Cues (How to Read Science, You Are There!)	Cues (How to Read Science, You Are There!)
<b>5</b>	Pictures	Pictures
<b>6</b>	Highlighting & note-taking	Highlighting & note-taking
<b>7</b>	Reviews	Reviews* (2)
<b>8</b>		Video* (1)
<b>9</b>		Interactivity* (2)
<b>10</b>		Audio* (1)





## **APPENDIX B**

### **Fidelity Checklist for iPad iBooks Instructional Design Rules**

# Fidelity Checklist for iPad eBooks Instructional Design Rules

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

CHAPTER: 1 2 3 4 5 6

	Page number	Content	Type of feature	Answer	Confirmation
Example	14	gravity	multiple choice	C - a force that moves or slows an object down	Yes
Review #1					
Review #2					
Video #1					
Widget #1					
Widget #2					
Audio #1					

## **APPENDIX C**

### **Reading Comprehension Test Example**

# Chapter 12 Review and Test Prep

## Use Vocabulary

<b>force</b> (page 332)	<b>motion</b> (page 327)
<b>friction</b> (page 333)	<b>position</b> (page 327)
<b>gravity</b> (page 336)	<b>relative position</b> (page 329)
<b>magnetism</b> (page 337)	<b>speed</b> (page 330)
	<b>work</b> (page 338)

Use the vocabulary term from the list above that best matches each statement.

1. If an object is in a different location, it has changed \_\_\_\_\_.
2. An object is in \_\_\_\_\_ if its position is changing.
3. A force that slows down a moving object is \_\_\_\_\_.
4. A push or a pull is a \_\_\_\_\_.
5. How fast an object changes position is its \_\_\_\_\_.
6. A change in position of one object compared to another object is its \_\_\_\_\_.
7. The non-contact force of \_\_\_\_\_ pulls any two objects toward each other.
8. The non-contact force of \_\_\_\_\_ pulls objects that contain iron.
9. If you use force to move an object, you have done \_\_\_\_\_.

## Explain Concepts

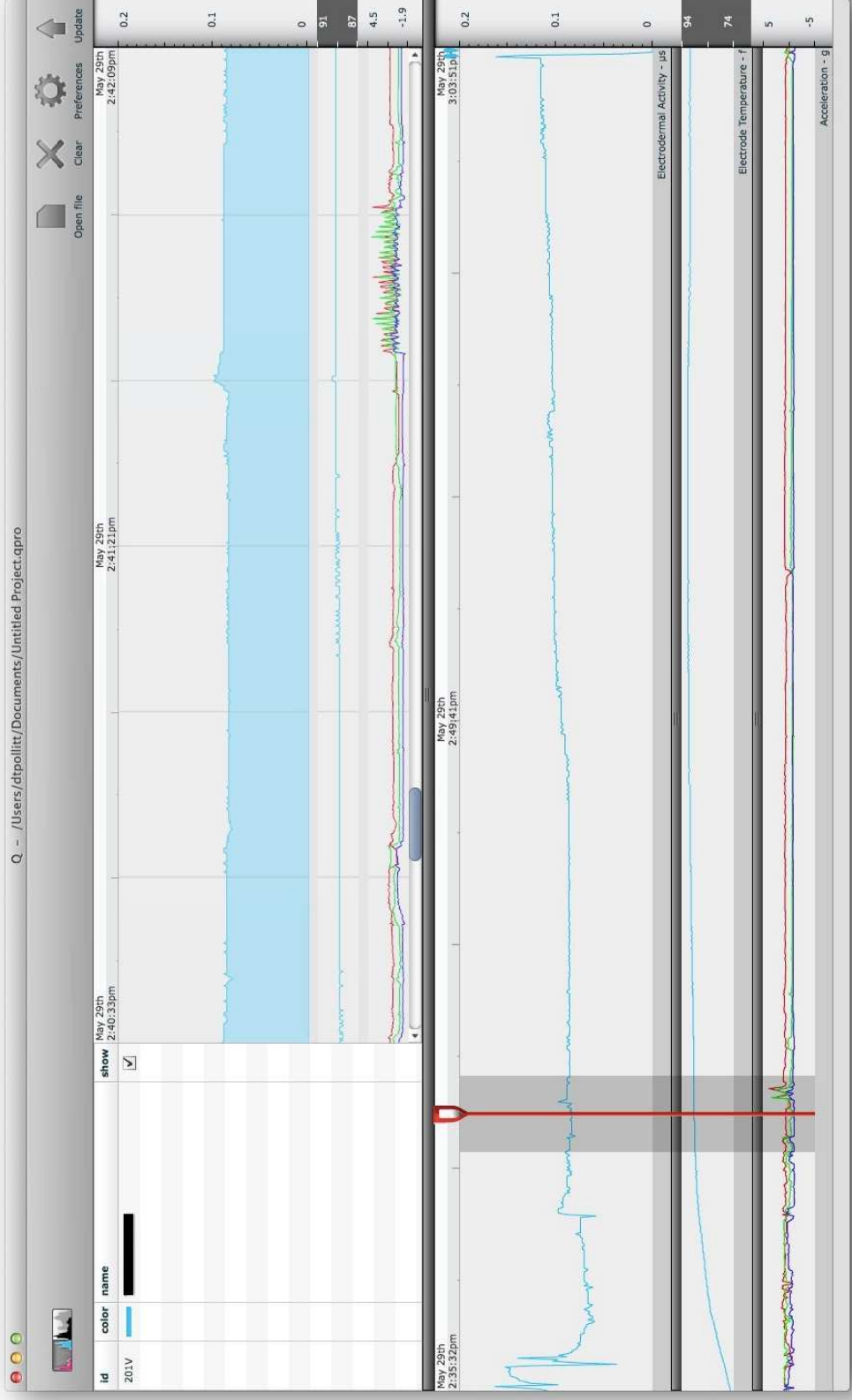
10. Explain how you can tell that an object is in motion.
11. A train is moving 435 kilometers (270 miles) per hour. A plane is flying 965 kilometers (600 miles) per hour. How much faster is the plane moving than the train?
12. Write a paragraph about a simple machine you have used and how it helped you do work.

## Process Skills

13. **Infer** what would happen to a thrown baseball if gravity and air friction did not affect it.
14. **Predict** how much more work you would do lifting two identical books compared to lifting just one.

## **Electrodermal Activity (EDA) Sample File**







## **APPENDIX E**

### **General Self-Efficacy Scale (GSES)**



**Generalized  
Self-Efficacy Scale (GSES)**

NAME: \_\_\_\_\_ DATE: \_\_\_\_\_

Please answer each question below. Answer each question by putting a "X" that best describes how you feel about the statements. A response of "1" means that the statement is **not true at all**, while a response of "4" means that the statement is **exactly true**.

	1 Not at all true	2 Hardly true	3 Moderately true	4 Exactly true
1 - I can always manage to solve difficult problems if I try hard enough.				
2 - If someone opposes me, I can find the means and ways to get what I want.				
3 - It is easy for me to stick to my aims and accomplish my goals.				
4 - I am confident that I could deal efficiently with unexpected events.				
5 - Thanks to my resourcefulness, I know how to handle unforeseen situations.				
6 - I can solve most problems if I invest the necessary effort.				
7 - I can remain calm when facing difficulties because I can rely on my coping abilities.				
8 - When I am confronted with a problem, I can usually find several solutions.				
9 - If I am in trouble, I can usually think of a solution.				
10 - I can usually handle whatever comes my way.				

Code # \_\_\_\_\_



## **APPENDIX F**

### **NASA Task Load Index (TLX)**



Workload

Exit

Instructions



**Mental Demand:**  
How mentally demanding was the task?

Very Low | Very High

**Physical Demand:**  
How physically demanding was the task?

Very Low | Very High

**Temporal Demand:**  
How hurried or rushed was the pace of the task?

Very Low | Very High

**Effort:**  
How hard did you have to work to accomplish your level of performance?

Very Low | Very High

**Frustration:**  
How insecure, discouraged, irritated, stressed, or annoyed were you?

Very Low | Very High

Performance: Please note that the following scale is a measure of how well you think you did on the task.

**Performance:**  
How successful were you in accomplishing the task?

Very Low | Very High

Continue





**APPENDIX G**

**Student Satisfaction Survey:**

**Textbook Version**

**and**

**iPad Version**



NAME: \_\_\_\_\_ DATE: \_\_\_\_\_

NAME: \_\_\_\_\_ DATE: \_\_\_\_\_

**Textbook  
Student satisfaction survey  
Chapter \_\_\_\_\_**

Please indicate how satisfied you are with the textbook. Answer each question by putting a "X" that best describes how satisfied you are with the items related to the strategy. A response of "1" means that you are **completely dissatisfied**, while a response of "6" means that you are **completely satisfied**.

Completely dissatisfied  
Completely satisfied

How satisfied are you that:	1	2	3	4	5	6
1 – the textbook helped you understand the chapter?						
2 – it was easy to use the textbook?						
3 – you can find the main idea of the chapter?						
4 – you can paraphrase the chapter?						
5 – you can use a textbook for other classes or outside of school?						
6 – you will be able to use a textbook on your own?						
7 – Overall, how satisfied are you with the textbook?						

Code # \_\_\_\_\_

NAME: \_\_\_\_\_ DATE: \_\_\_\_\_

NAME: \_\_\_\_\_ DATE: \_\_\_\_\_

**iPad eBooks textbook  
Student satisfaction survey  
Chapter \_\_\_\_\_**

Please indicate how satisfied you are with the iPad eBooks textbook. Answer each question by putting a "X" that best describes how satisfied you are with the items related to the strategy. A response of "1" means that you are **completely dissatisfied**, while a response of "6" means that you are **completely satisfied**.

*Completely dissatisfied*                      *Completely satisfied*

<b>How satisfied are you that:</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
1 – the iPad eBooks helped you understand the chapter?						
2 – it was easy to use the iPad eBooks textbook?						
3 – you can find the main idea of the chapter?						
4 – you can paraphrase the chapter?						
5 – you can use an iPad eBooks textbook for other classes or outside of school?						
6 – you will be able to use an iPad eBooks textbook on your own?						
7 – Overall, how satisfied are you with the iPad eBooks textbook?						

Code # \_\_\_\_\_



## **APPENDIX H**

### **Semi-structured Interview Questions:**

**Pre-study**

**and**

**Post-study**



## **Questions for interview #1: Pre-study**

### **Tell me how you use iPad iBooks**

1. How did you hear about iPad iBooks?
2. How long have you used iPad iBooks?
3. What are some of the things you have heard about iPad iBooks or used them for?

### **Tell me what you are learning through iPad iBooks**

4. What about iPad iBooks helps your learning?
5. What about iPad iBooks hurts your learning?
6. How is your learning different on a traditional textbook compared to an iPad iBooks?

### **Tell me your opinions of iPad iBooks**

7. What specifically do you like about iPad iBooks?
8. What specifically do you dislike about iPad iBooks?
9. Do you have a preference of how and when you would like to use iPad iBooks during a typical school day?
10. When you look at iPad iBooks, what do you find interesting?
11. Now that you have used iPad iBooks, what would you tell your teacher to do differently when they teach?
12. Is there anything else that we did not discuss today that you would like to share?





## **Questions for interview #2: Post-study**

### **FEATURES**

1. Talk to me about the features of an iPad. Here is the list of all 10. Which ones do you think are really useful?
2. Which features do you think aren't that useful?
3. What feature do you think you used the most? The least?
4. Any other comments you'd like to make about features?

### **READING**

5. Do you read with an iPad at home or school? Tell me about that. What do you read? How often? What type of reading?
6. Thinking again about what you read, how often you read, and what type of reading you do on an iPad, how is your reading experience different on the iPad when compared to the traditional textbook?
7. Do you think you remember better, worse, or about the same when reading on an iPad as compared to a traditional textbook?
8. During a typical school day, are there times or class periods that you think the use of an iPad iBook would be most helpful?
9. Do you have any other comments about reading on an iPad?

### **OTHER**

10. What did you learn about the iPad during this study?
11. Did anything surprise you during this study?
12. Is there anything else that you haven't shared with me today that you would like to now?

**APPENDIX I**

**Teacher Protocol for Instruction**

## TEXTBOOK INSTRUCTION

### STAGE 1: DESCRIBE - Provide an advance organizer of textbook features (20 min)

#### PURPOSE

This stage will ensure that students understand the features of a textbook.

#### MATERIALS

- Middle school science text: *Scott Foresman Science: Life Science Chapter 1: Plants and How They Grow*
- Copies of FRAME graphic organizer
- Folders for storing student materials
- Pencils & highlighters
- Sticker labels for student pseudonyms on folders
- Black board & chalk

#### PROCEDURES

1. Today we are going to learn how to find important information from a textbook. You probably already use a textbook in your classes.
  - a. *How many of you already use a textbook in your classes?* [Elicit responses]
2. Well, today I am going to teach you a few strategies to use when learning from a textbook. You will learn: [Write on board]
  - a. How to navigate through a textbook
  - b. How to find important information
  - c. How to review important information
3. First, let's look at a textbook. Scan through the chapter front to back; I will give you 2 minutes to do this. [Pull out textbook; wait 2 minutes] I am going to describe one feature of a textbook, and then I would like you to describe other features of a textbook, too. Okay, so one feature of a textbook is that it includes a **table of contents**. It helps you navigate in a book, chapter, or lesson.
  - a. *Can you think of other features of a textbook?* [Elicit responses: **Glossary & vocabulary, text clues, cues, pictures, highlighting & note-taking, reviews**]
4. Great, now that we learned the features of a textbook, let's fill out a FRAME to visualize what we just said. [Hand out FRAME; fill out with responses elicited above] As I write these on the board, follow along and fill them out, too. Super! Now we both understand the important features of a textbook. Let's look a bit more at how to use these features.

## STAGE 2: MODEL & PRACTICE - How to use the features of a textbook (20 min)

### PURPOSE

This stage will ensure that students are able to use the features of a textbook.

### MATERIALS

- Same as previous stage

### PROCEDURES

1. Now that we understand all the features of a textbook, we will learn how to use them. Let's review the FRAME we just created. Please pull out your textbook FRAME. [Display FRAME and review features].
2. One important feature of a textbook I mentioned earlier is that it includes a **table of contents**. Flip the textbook to the table of contents and find Lesson 1: What are the main parts of a plant? Go to that page now. [Wait for all students to find page 2] GREAT! You just used the first feature of a textbook—the table of contents.
3. Now that you learned how to use the first feature of a textbook, let's learn how to use the other six features of a textbook. [Teachers: Follow the above script to teach the five other textbook features bolded below. Be sensitive to explicitly modeling each feature and check for understanding with each student.]
  - a. **Glossary & vocabulary** (p. 8): system in Lesson 1 & associated glossary term in back of book
  - b. **Text clues** (p. 8-9): bold, font color & size
  - c. **Cues** (p. 6): You Are There!
  - d. **Pictures** (p. 2-3): vocabulary words & associated pictures
  - e. **Highlighting & note-taking** (p. 8-9): highlight word *system* and sentence
  - f. **Reviews** (p. 7): checkpoint
4. Great, now that we understand how to use the features of a textbook, let's find and highlight important information. Remember when we found the word system?
  - a. *Why do you think that word is so important?* [Elicit responses]
  - b. That's right! System is an important word because it uses many of the features in the textbook we have been talking about. First, it is a vocabulary word on page 3. It is found again as a bolded text clue on page 8. Finally, we can find it in the back of the book in the glossary.
  - c. Now we should go ahead and highlight the word system. Let's go to the glossary and highlight that word, too. [Wait for students to do the same]
5. Are there other vocabulary words on this page we should highlight? [No]
6. Finally, you should also know that you can write in your textbook. Go to page 7. Read the two paragraphs on this page, and when you are finished, underline the four things plants and animals need to live.
  - a. *Super! You should have underlined food, air, water, and space.*
7. Now you have learned how to use all of the features of a textbook!

## iPAD iBOOKS INSTRUCTION

### STAGE 1: DESCRIBE - Provide an advance organizer of iPad iBook features (25 min)

#### PURPOSE

This stage will ensure that students understand the features of iPad iBook.

#### MATERIALS

- iPads iBook of middle school science text: *Scott Foresman Science: Life Science Chapter 1: Plants and How They Grow*
- Copies of FRAME graphic organizer
- Folders for storing student materials
- Sticker labels for student pseudonyms on folders
- Black board & chalk

#### PROCEDURES

1. Today we are going to learn how to find important information from an iPad iBook. You may already use an iPad iBooks in your classes.
  - a. *How many of you already use an iPad iBook in your classes?* [Elicit responses]
2. Well, today I am going to teach you a few strategies to use when learning from an iPad iBook. You will learn: [Write on board]
  - a. How to navigate through an iPad iBook
  - b. How to find important information
  - c. How to review important information
3. First, let's look at an iPad iBook. Using your finger to swipe, scan through the chapter, front to back, I will give you 2 minutes to do this. [Pull out iPad iBook; wait 2 minutes] I am going to describe one feature of an iPad iBook, and then I would like you to describe other features of an iPad iBook, too. Okay, so one feature of an iPad iBook is that it includes video. Videos include moving pictures and audio.
  - a. *Can you think of other features of an iPad iBook?* [Elicit responses; should include: **Table of contents, glossary & vocabulary, text clues, cues, pictures, highlighting and note-taking, reviews, video, interactivity, audio**]
4. Great, now that we learned the features of an iPad iBook, let's fill out a FRAME to visualize what we just said. [Hand out FRAME; fill out with responses elicited above] As I write these on the board, please follow along and fill them out, too. Super! Now we both understand the important features of an iPad iBook. Let's look a bit more at how to use these features.

## STAGE 2: MODEL & PRACTICE - How to use the features of an iPad iBooks (25 min)

### PURPOSE

This stage will ensure that students are able to use the features of an iPad iBook.

### MATERIALS

- Same as previous stage

### PROCEDURES

1. Now we are going to focus on learning how to use all the features we just discussed. Let's review the FRAME we just created. Please pull out your textbook FRAME. [Display FRAME and review features].
2. One important feature of an iPad iBook I mentioned earlier is that it includes **video**. Find Lesson 1: What are the main parts of a plant? Search for the video on plants breathing. [Wait for all students to find video] GREAT! You just used the first feature of a textbook—video.
3. Some of the features in an iPad iBooks are exactly the same as in a textbook.
  - a. *Can you guess which features are the same on both textbooks?*
  - b. Great! The same features on both the textbook and iPad iBooks textbook are: **table of contents, glossary & vocabulary, text clues, cues, pictures, highlighting and note taking, and reviews.**
  - c. Some features are different, though. *Can you tell me some features that are different between a textbook and an iPad iBook?*
  - d. Super! **Video, interactivity, and audio** are different because they cannot be found in a textbook, but can be found in an iPad iBook.
4. Now that you learned how to use the first feature of an iPad iBook—video—let's learn how to use the other eight features of an iPad iBook. [Teachers: Follow the above script to teach the nine other textbook features bolded below. Be sensitive to explicitly modeling each feature and check for understanding with each student.]
  - a. **Table of contents:** navigation in beginning of book
  - b. **Glossary & vocabulary:** system in Lesson 1 & associated glossary term
  - c. **Text clues:** bold, font color & size in Lesson 1
  - d. **Cues:** You Are There! in Lesson 1
  - e. **Pictures:** Gallery 1.1
  - f. **Highlighting & note-taking:** system in Lesson 1 & sentence
  - g. **Reviews\*:** Review 1.1
  - h. **Videos\*:** as noted above
  - i. **Interactivity\*:** Interactive 1.1
  - j. **Audio\*:** Audio 1.1
5. Great, now that we understand how to use the features of an iPad iBook, let's find and highlight important information. Remember when we found the word system?
  - a. *Why do you think that word is so important?* [Elicit responses]
  - b. That's right! System is an important word because it uses many of the features in the iPad iBook we have been talking about. First, it is a vocabulary word. It is found again as a bolded text clue. Finally, we can find it in the back of the book in the glossary.

- c. Now we should go ahead and highlight the word system. Choose a color to highlight the word. Do you want to write a note for the word? Let's type "A plant and its leaves work together in a system to grow and flourish." [Wait for students to do the same]
6. So you should know that you can take notes in your iPad iBook, too, just like a regular textbook. Let's do that one more time. Go to the first page of Lesson 1 and find the section talking about the main parts of a plant. Read the two paragraphs on this page, and when you are finished, highlight the four things plants and animals need to live.
  - a. *Super! You should have underlined food, air, water, and space*
7. Now you have learned how to use all of the features of an iPad iBook!



## PRIMING ACTIVITY INSTRUCTION (5 min)

### PURPOSE

This stage will ensure that students recall and are able to use the features of both book types. It should be the opening activity for each student prior to reading a book chapter (6 total).

### MATERIALS

- Middle school science text: *Scott Foresman Science* or iPads iBook of middle school science text: *Scott Foresman Science*
- Completed student copy of FRAME graphic organizer

### PROCEDURES

1. Please put on your Q-Sensor. [Wait] GREAT! The green light should be flashing, and that means it's on and recording. Now we are going to review the features of your [textbook / iPad iBook]. Please pull out your FRAME.
2. *What is the purpose of book features?* [Wait for responses.] That's right! Book features help us find important information. How many features are in the book you are using today? [7 textbook, 10 iPad iBook]
3. Since we have already learned about specific book features, right now I want you to prove to me that you know how to find each feature. This won't take very long—only 1 or 2 minutes. Let's start.
  - a. Textbook and iPad iBook shared features:
    - i. *Can you find me the **table of contents** in your book?*
    - ii. *Find any **vocabulary** word, then locate it again in the **glossary**.*
    - iii. *Pick any page and identify all the **text clues** on the page.*
    - iv. *Where is the **You Are There!** in this chapter?*
    - v. *Flip through some **pictures** for me.*
    - vi. *What would be valuable information to **highlight** or **take notes** on?*
    - vii. *Where are the lesson or chapter **reviews**?*
  - b. iPad iBook features:
    - i. *Where is a **video** to watch?*
    - ii. *Can you find an **interactive**?*
    - iii. *Find an **audio** clip.*
4. GREAT! I think you are ready to start reading this chapter. Remember to keep your FRAME on your desk where you can see it, and I've recorded all the book features on the black board, too. If you have any questions, let me know. Good luck!

## **APPENDIX J**

### **Task Analysis Checklist**

## Chapter 1: Features of iPad textbooks task analysis checklist

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

	Textbook	Chapter 1 model	Chapter 1 practice	Answer	Confirm student accuracy
1	Table of contents	p. vi - xix	How many lessons are there in Chapter 1?	5	
2	Glossary & vocabulary	p. 8 <i>system</i> & glossary em7	Where can you find the glossary word deciduous?	p. 14 & em3	
3	Text clues (bold, italic, underline, font, color, size)	p. 8 - 9 bold, font color & size	Find some text clues on p. 10 - 11	Bold, font, color	
4	Cues (How to Read Science, You Are There!)	p. 6 You Are There! p. 5 How to Read Science	N/A	N/A	
5	Pictures	p. 2 - 3 vocabulary words & associated pictures	What are some other types of stems found in lesson 2?	p. 13 potato, vine, tree, rhubarb	
6	Reviews	p. 7 checkpoint	Is there a checkpoint in lesson 2?	p. 11	

Code # \_\_\_\_\_

## Chapter 2: Features of books task analysis checklist

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

	Textbook	Chapter 2 model	Chapter 2 practice	Answer	Confirm student accuracy
1	Table of contents	p. vi - xix	How many lessons are there in Chapter 2?	4	
2	Glossary & vocabulary	p. 40 <i>trait</i> & glossary em7	Where can you find the glossary word vertebrate?	p. 40 & em8	
3	Text clues (bold, italic, underline, font, color, size)	p. 42 - 43 bold, font color & size	Find some text clues on p. 44 - 45	Bold, font, color	
4	Cues (How to Read Science, You Are There!)	p. 38 You Are There! p. 37 How to Read Science	N/A	N/A	N/A
5	Pictures	p. 34 - 35 vocabulary words & associated pictures	What are groups of vertebrates found in lesson 1?	p. 41 fish, amphibians, reptiles, birds, mammals	
6	Reviews	p. 39 checkpoint	Is there a checkpoint in lesson 2?	p. 45	

Code # \_\_\_\_\_