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# Literacy, Equity, and the Employment of iPads in the Classroom: A Comparison of Secure and Developing Readers

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# Literacy, Equity, and the Employment of iPads in the Classroom: A Comparison of Secure and Developing Readers

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**Abstract**

This study explored 6th grade students reading of science text on the iPad to better understand how students with varying strengths of comprehending text and current academic abilities interpret text on their iPads. Our study sample compared three students with strong reading scores based on informal reading inventories, standardized tests, and other literacy measures with students who have not yet demonstrated strong reading scores on the same assessments. Verbal protocols allowed us to look at individual student's cognitive processes while reading assigned science text on the iPad. We analyzed data based on the theory of Constructively Responsive reading (Pressley & Afflerbach, 1995). Our data shows that while secure readers fit Pressley and Afflerbach's description of a 'massively active' reader, verbal protocols for developing readers revealed students' difficulty constructing meaning with the text. In addition, self-efficacy and navigational skills on the iPad differed between secure and developing readers. The differences in processing between students in our secure and developing groups points to the need for increased support for developing readers as they navigate reading of science texts on the iPad.

## Introduction

How do students with varying academic strengths comprehend science text read on their iPads? In this study, we used verbal protocols and classroom observation to answer this question. This is a timely study. The Common Core standards have increased text complexity for all readers (Hierbert, 2013). Technology integration is moving quickly into classrooms across the country, and the gap between readers online comprehension is wide (Leu, Forzani, Rhoads, Maykel, Kennedy & Timbrell, 2014). ). The ability to learn new information from texts is critical as this ability influences academic success from elementary school through college, and even into the workplace (Duke & Carlisle, 2011). In this article we examine comprehension processes of secure and developing readers as they read digital text on the iPad and consider equity in regards to access to this content.

### Factors That Influence Individual Reader's Comprehension

It is clear that readers differ in their interactions with and processing of texts. Some of these differences are based on individual differences in background knowledge (McNamara & Kintsch, 1996), individual differences in higher-level processes (Kendou, van den Broek, Helder & Karlsson, 2014; Rapp, Broek, McMaster, Kendeou & Espin, 2007), and individual differences in standards of coherence (van den Broek, Bohn-Gettler, Kendou & Carlson, 2011). Background knowledge supports every aspect of reading, not only by providing a base of information but also by influencing how readers interact with texts (Brozo, 2010). In a study that investigated background knowledge with high and low ability readers, background knowledge was shown to better predict outcomes in reading than reading skills (Recht & Leslie, 1988). In this study, background knowledge was such a powerful factor in comprehension that students who struggled with comprehension, but had high knowledge in relation to a particular text, demonstrated stronger understanding of the text than secure readers.

Knowledge is not simply acquired by reading a text though. The cohesion of texts also impacts learning. A study that manipulated levels of text cohesion demonstrated that the match of background knowledge with cohesion in texts is important for learning (McNamara & Kintsch, 1996). Greater text cohesion supported learning, recall, and memory for readers with low background knowledge in relation to the text, whereas gaps in the cohesion of texts supported learning, recall, and memory for readers with high background knowledge in relation to the text.

Individual differences in higher order processes such as working memory, attention allocation, and inference making influence information gained from reading (Kendeou, van den Broek, Helder & Karlsson, 2014). Working memory is the ability to maintain information in memory while processing incoming information, and this is particularly important when a task is challenging. Budd, Whitney & Turley (1995) examined individual differences in working memory while reading expository texts and discovered that students with lower working memory struggled to answer detail questions of texts. Students with higher working memory in this study increased their thematic processing in order to retain the detailed information, adjusting their strategies to accommodate different tasks and materials. Attention allocation is the ability to adapt attention and processing based on the fluctuating nature of a task. When attention allocation is not strong, readers may be more distracted by details that are irrelevant to the main ideas in a text (Kendeou et al., 2014). Further, students who struggle with comprehension often have difficulty generating inferences while reading (Cain, Oakhill, Barnes & Bryant, 2001). Generating inferences while reading is critically important because reading comprehension requires readers to fill in information that is left implicit in the text.

Individual differences in standards of coherence also influence information gained from reading texts (van den Broek et al., 2011). Standards of coherence are the level of understanding a reader aims to achieve for an individual text (Kendeou et al., 2014). If a reader's standard of coherence is not met while reading a text, secure reader's engage in strategic processes, such as rereading and drawing on prior knowledge, to achieve coherence; however, students who struggle with comprehension often do not recognize inconsistent information, draw on prior knowledge, or engage in strategic processes to improve their understanding of the text (van den Broek et al., 2011). As students read challenging informational texts, the ability to navigate through the text becomes even more critical for students who know less content in the text.

**Reading Texts on the iPad**

There is a close relationship between internal cognitive processes involved with comprehension and the use of external digital material like the iPad (Lawless & Schrader, 2008; Simpson, Wash & Rowsell, 2013). Simpson, Walsh & Rowsell (2013) studied the physical and cognitive reading pathways as students processed texts on the iPad and found that readers actively shifted between reading, processing, thinking about content, problem solving, and utilizing strategies specific to making meaning on the iPad. In addition, readers paused to manipulate text, such as enlarging font and following hyperlinks. The authors concluded that the act of reading on the iPad is active, dynamic, and complex. To understand text on the iPad, readers engage in physical processes of touch and manipulation along with cognitive processes that support intertextuality, multidirectionality and metatextual awareness. These processes extend the cognitive processes of traditional text by placing additional demands on the integration of information between texts and the flexibility needed to adapt attention to an increasingly fluctuating task.

Compared to the research regarding use of the iPad and reception for iPad initiatives, far less research exists on the academic impact devices have on student learning (HaBler, Major & Hennesy, 2015). Early studies on the use of the iPad and digital devices in English/language arts classes examined the potential benefits and drawbacks of using the device as an e-reader in lieu of printed materials. For example, Huang, Liang, Su and Chen (2012) developed an interactive e-back learning system (IELS) for elementary students in hopes of encouraging them to use e-books for learning. Although popular with students, no significant difference was found between groups (Huang et.al., 2012). In an interdisciplinary study conducted at Indiana University-Purdue University, Miller (2012) found that students self-reported that iPad use contributed to increased learning and engagement. When students were asked to provide more detail, they described the "ease with which information could be accessed via Internet connectivity, convenience and portability and the fun factor". Although students in this study described their learning positively, no data were collected to examine whether or not learning did occur and specifically how students used the devices. Miller noted that "further study . . .is needed to assess the achievement of specific learning outcomes" (p. 58), a common sentiment across the research reviewed.

**Theoretical Framework**

Think aloud studies have helped shape our understanding of reading processes and the act of reading. Pressley and Afflerbach's (1995) synthesis of 40 verbal protocol studies led to a theory of reading comprehension called

Constructively Responsive reading. Constructively Responsive reading takes into account Schema Theory and the importance of prior knowledge (Anderson & Pearson, 1984), Reader Response theory (Rosenblatt, 1978), comprehension monitoring and metacognition (Baker and Brown, 1984), and making inferences while reading (Graesser, Singer & Trabasso, 1994). According to the theory of Constructively Responsive reading, reading comprehension is a ‘massively active’ process before, during, and after reading. The theory of Constructively Responsive reading provides a summary of thinking processes of secure readers organized into categories. These categories allowed us to align verbal protocol statements of students in our study with the catalogued processes of secure readers.

Models of cognitive processes describe the cyclical nature of comprehension for both online and offline reading. The Landscape Model of reading (van den Broek et al., 2011) describes reading comprehension as a parallel activation of information in the text along with related prior knowledge in memory. When information is activated, it spreads and links to related concepts throughout reading, strengthening conceptual understanding and memory; however, when concepts and ideas are not well connected in the text or with prior knowledge, they drop out of activation while students read. According to the Landscape Model, each reader adopts a standard of coherence for different texts based on text relevance and reading goals (van den Broek et al., 2011). These standards of coherence are unique for each reading event and influence attention and focus throughout reading. Standards of coherence assume individual differences among readers’ mental representations of the same text based on individual reader’s unique criteria for comprehension.

The Structure Building model of comprehension (Gernsbacher, 1990) explains why knowledge is not simply acquired by reading a text. The Structure Building model describes comprehension as a process of laying a foundation when confronted with new information in a text and then mapping related information onto that foundation, creating a structure. If new information cannot be mapped onto an existing foundation, readers shift to lay a new foundation. Strong comprehension depends on incorporating relevant new information to an existing foundation and also being able to suppress irrelevant information (McNamara & Magliano, 2009). Students who struggle may have difficulty mapping relevant information onto a foundation and become confused by trying to maintain too many substructures.

## Method

In this section we describe the details of this mixed methods comparative case study, starting with a description of the setting, participants and materials. After this we explain our data collection and analysis procedures.

Table 1. Description of participants

| Student | NWEA (2014-15) | Fountas and Pinnell BAS (2014-15) | Developing/ Secure |
|---|---|---|---|
| Nadine | 42% RIT 208<br>Lexile$^R$ Range<br>645-795L | Independent level S<br>99% Decoding Accuracy<br>Satisfactory Comprehension | Developing |
| James | 9% RIT 191<br>Lexile$^R$ Range<br>339-489L | Independent level R<br>98% Accuracy<br>Satisfactory Comprehension | Developing |
| Ana | 55% RIT 213<br>Lexile$^R$ Range<br>735-885L | Independent Reading Level T<br>100% Accuracy<br>Excellent Comprehension | Developing |
| Bill | 87% RIT 228<br>Lexile$^R$ Range<br>1005-1155L | Independent Reading Level W<br>99% Accuracy<br>Satisfactory Comprehension | Secure |
| Hillary | 92% RIT 232<br>Lexile$^R$ Range<br>1077-1227L | Independent Reading Level X<br>98% Accuracy<br>Excellent Comprehension | Secure |
| Pharoah | 79% RIT 223<br>Lexile$^R$ Range<br>915-1065L | Independent Reading Level X<br>99% Accuracy and<br>Excellent Comprehension | Secure |

### Participants

In this comparative case study we collected data from six 6th grade students within one classroom, attending a Midwestern, suburban elementary school (Table 1.) Students were selected and grouped based on their Northwest Education Assessments (Northwest Education Association, 2003) scores at multiple time points, Fountas & Pinnell Benchmark Assessment System (Fountas, 2008) informal reading inventory, classroom observation, reading response journals and writing samples. Based on the result of these assessments, students were categorized as "secure" or "developing" in regards to consistent demonstration of successful reading.

### Materials

The text used in this study was from the Minnesota Grade 6 Science FlexBook[R] from the 2012 CK-12 Foundation. The goal of the CK-12 Foundation, is to "reduce the cost of textbook materials for the K-12 market" worldwide. In this way, materials used in the study are available free to other interested readers. "All CK-12 Content (including CK-12 Curriculum Material) is made available to users in accordance with the Creative Commons Attribution-Non Commercial 3.0 Unported (CC BY-NC 3.0) License (http://creativecommons.org/licenses/by-nc/3.0/)" (Minnesota Grade 6 Science, iBook, CK-12 - www.ck-12.org). All students in the classroom were assigned the same text to read on Motion (pages 134-164). Running records confirmed that the decoding of text matched the instructional and independent levels of the readers.

### Data Collection

Verbal protocols allowed us to look at student processes of reading science texts on the iPad. According to J.P. Magliano and A. C. Graesser (McNamara, 2007), those who have used validity measures for verbal protocol analysis found a very high correlation between self-reports and performance. Over the span of two weeks, students met in a quiet room with the researcher for approximately 30 minutes per student on 3 separate days. During this time students read their assigned science texts on their iPads and shared thinking out loud. Cueing for the reader was general based on the recommendation of Pressley and Hilden (Mallette & Duke, 2004). The cue, "What are you thinking about your reading?" was provided before, during, and after reading. Students were also instructed to stop at any point in their reading to share their thinking out loud. Individual student's reading and thinking was audio recorded. A total of 196 minutes of audio recorded reading and think aloud statements were collected.

Data were also collected through two hours of classroom observation during which time the two researchers walked around the class listening to students read their science text on the iPad. In addition, researchers observed the hyperlink use of individual students. All students in the classroom completed a survey that included a prompt asking them to describe their use of iPad features such as hyperlinks to video and additional visual models. In addition, at the end of the study a brief interview with each student in the study provided an opportunity to ask students about their use of hyperlinks in order to check our assumptions and interpretations of the student's responses (Creswell & Miller, 2000).

### Data Analysis

Data were analyzed based on the theory of Constructively Responsive reading (Pressley & Afflerbach, 1995). First, audio recordings for each student were transcribed onto separate copies of the texts by the first author. Next, all thinking statements for developing readers were listed in a table that displayed thinking statements made by developing readers before, during and after reading all three texts. The same table was created for secure readers to provide a comparison between secure and developing readers. An example of a thinking statement made by a secure reader was, "I'm inferring that velocity means speed and direction." A summary of the frequency of thinking statements made by secure and developing readers before, during, and after reading were created in Table 2. Next both researchers independently placed all thinking statements for the secure and developing readers in a document that listed categories of thinking processes identified through Pressley and Afflerbach's theory of Constructively Responsive reading (1995). For example, the thinking statement "I'm inferring that velocity means speed and direction" was assigned the category Conscious Inference Making. The only verbal protocol statements that did not fit a category in this study were statements that reflected the idea that students were not thinking anything. After that, researchers created Table 3 to provide a summary of categories evident in students' verbal protocol statements. Inter-rater reliability for the placement of these thinking statements into categories was 81%. Though a number of statements had the potential to fit more than one category, each statement was assigned only one category. Differences in identifying the best placement were negotiated between researchers. A week later, the first author met individually with each student for a member check and validated data.

## Results

Data analysis with verbal protocols and classroom observation revealed that secure and developing readers differed in their amount of thinking statements, placement and type of thinking statements, and navigational skills with digital texts.

### Differences in the Amount and Placement of Thinking Statements

Different amounts of thinking can be seen by counting the number of statements made by students before, during and after reading (Table 2). Secure readers provided a total of 64 thinking statements and developing readers provided a total of 23 thinking statements.

Table 2. Total number of thinking statements

| | Before | During | After | Total |
|---|---|---|---|---|
| Secure Comprehension | 7 | 38 | 19 | 64 |
| Developing Comprehension | 9 | 3 | 11 | 23 |

In our study, secure readers initiated the majority of their thinking statements without a prompt, and these statements most often occurred during reading. In comparison, developing readers shared statements when prompted, and these statements most often occurred before or after reading. The absence of developing reader thinking-statements *during* reading may be related to higher-order cognitive processes such as working memory or attention allocation. Students needed to retain information from reading that appeared challenging in content while processing incoming information. This complex higher order process puts a strain on readers' comprehension, particularly if background knowledge related to the text is not strong. The alignment of thinking statements to categories also revealed a large difference in the processing of text between the secure and developing readers (Table 3).

Table 3. Categories adapted from constructively responsive reading (Pressley & Afflerbach, 1995)

| | **Secure Readers** | **Developing Readers** |
|---|---|---|
| **Before Reading** | | |
| Generating a hypothesis about content of the text. | 4 | 4 |
| **During Reading** | | |
| Identifying important information in the text | 2 | |
| Conscious inference making | 6 | |
| Monitoring comprehension | 7 | 1 |
| Interpreting | 5 | |
| Restating part of the text | 1 | |
| Predicting/substantiating on predictions | 5 | |
| Evaluating style or content | 2 | |
| Adjusting original ideas | 1 | |
| **After Reading** | | |
| Monitoring that the text is understood | 4 | |
| Listing pieces of information in the text | 5 | 1 |
| Imagining how hypothetical situations might be viewed in light of information from text | 1 | |
| Reflecting on information… possibly shifting interpretations | 1 | |
| Evaluating and reconstructing an understanding | 3 | 1 |
| **Total statements of conscious processing** | 47 | 7 |

## Secure Readers

When placing thinking statements in preset categories adapted from Constructively Responsive reading, secure readers fit Pressley and Afflerbach's (1995) description of a 'massively active' reader. Thinking statements for secure readers demonstrated an active search for overall meaning of text. Students shared predictions as they read and drew on their prior knowledge. New information either confirmed the accuracy of predictions or shifted understanding to account for new learning and enriched understanding of concepts. An interest in learning about concepts in the text was stated, and texts were evaluated based on their effectiveness in helping students learn. Thinking statements often demonstrated the recursive nature of constructing meaning with texts. The following statement exemplifies verbal protocols provided by secure readers in this study.

> Well I know that a force means a push. So something is going to have to be going in motion if it's going to have force in it.

In this example, the student drew on prior knowledge, and this prior knowledge interacted with the words on the page leading to an inference. This inference enriched the text representation and led to a prediction about important upcoming information in the text. This process was fluid, active and cyclical in deepening conceptual understanding within this text. Secure readers gained new knowledge through independently reading this text.

## Developing Readers

Verbal protocols for our developing readers also began with predictions about what would be read; however, developing readers rarely initiated thinking statements *as* they read, and when prompted to share their thinking, the most common statement in 70% of their responses was, "I'm not thinking anything". Following is an example of a thinking statement provided by a developing reader.

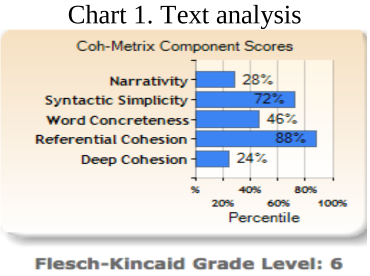
> Nothing. I was thinking nothing. When I read a book it gives me words and says what they're doing. When I read this it doesn't show anything… No pictures or imagination.

This example demonstrates the student's difficulty of constructing meaning with this text. The student did not appear to lay a foundation of meaning and map related information onto that structure (Gernsbacher, 1990). This reader, along with the other developing readers in our study appeared to read the text effortlessly; yet the cognitive processes of determining important information, drawing on background knowledge, making inferences, strengthening conceptual understanding, adapting attention to the fluctuating nature of a task, and monitoring comprehension were not evident. When considering the construction of understanding and building of knowledge from the text, the three developing readers ended each of the three classes at a disadvantage compared to the secure readers. Content in the text was missed, and this content would be needed to make sense of the upcoming readings. It is unlikely that decoding put a strain on comprehension since decoding accuracy for developing readers averaged 97% in these texts.

## Digital Text Features

The school district guidelines stipulated that all students learn science curriculum content by reading on the iPad. According to Flesch-Kincaid metrics, the grade level of this text was appropriately matched to sixth grade students; however, the words in this text, offered on the iPad, were not differentiated for the different background knowledge of students nor differentiated for different academic abilities of readers. We analyzed text complexity through the use of Coh-Metrix (Graeeser, McNamara, Kulikowich, 2011), a computer facility that analyzes five dimensions of text difficulty based on a multilevel theoretical framework (Chart 1).

Chart 1. Text analysis



Coh-Metrix component scores determined that the science text read by students is syntactically simple for a sixth grade student. Words per sentence, sentence structure, and number of sentences in a paragraph all provide access to content for students. In addition, referential cohesion was strong. The content overlap, argument overlap, type token ration, and LSA overlap demonstrate a well-connected text, and this level of referential cohesion is supportive of developing readers (McNamara & Kintsch, 1996). Deep cohesion, however, was very low in this text. Deep cohesion refers to the goal oriented, causal connections in the text. Though syntactically simple, and each section of text were fairly short, the texts were not well connected to goals and relationships of ideas across the entire text. Word concreteness and narrativity were also low, providing an additional challenge for developing readers. Narrativity refers to the story-like quality of the text, affiliated with common oral conversation. Word concreteness refers to words in a text that are easy to represent visually, and the lower levels of narrativity and word concreteness made this text more difficult to process and understand for developing readers.

The science text on the iPad did provide opportunities for developing readers who were struggling with content to learn more through clicking on hyper-links. The hyperlinks in this text brought students to short videos and visual models that explicitly demonstrated content previously read in the text. Labeling for these hyperlinks was explicit. For example, students read sentences such as:

> This (link) will provide you with a good hands-on introduction to the concept of force in physics.
> You can learn more about the concept of net force at this URL.
> If you need more practice calculating net force, go to this URL.

Developing readers ignored all of these hyperlinks. Self-efficacy and navigational skills on the iPad were not evident in observations of developing readers or in the developing readers' self-reports during the final interview. In contrast, secure readers reported clicking on the links half to most of the time and explained that the videos were helpful if they felt confused or wanted to better understand the concept. According to the Landscape Model of Reading (van den Broek et al., 2011), readers adopt a unique standard for comprehending text for each reading event. This standard is based on a combination of factors, such as individual goals for reading, text relevance, and interest in the subject. The student's standard of coherence initiates processes to better understand texts, and this was seen through the secure readers' decision to click on hyperlinks. The standards of coherence exhibited by developing readers differed, and information that could be accessed through hyperlinks was missed for the developing readers. iPad features that may enhance learning for secure readers may also place an extra demand on developing readers. Navigating text on the iPad involves multidirectionality and intertextuality, and this requires higher order processes of comprehension, such as working memory and adapting attention to the fluctuating nature of a task. Developing readers in this study did not move their attention away from reading the text on the page.

## Conclusions and Recommendations

Our study revealed that foundational literacy instruction is imperative regardless of the medium of the text read. We have several suggestions to support developing readers in gaining conceptual understanding and knowledge from reading science texts on iPads. First, science texts may be too complex for many readers to create a coherent mental representation of their reading. Differentiated texts could be provided on the iPad with varying levels of complexity and cohesion, allowing all readers access to content knowledge. A benefit in using differentiated texts on iPads is the privacy for developing readers in holding a device (text) that looks the same as the device (text) for secure readers. Second, bundling texts for science topics and spending a longer amount of time with reading in one content area could support developing readers in gaining conceptual understanding from reading. The cognitive process of laying a foundation of knowledge on which to attach new knowledge is necessary for learning (McNamara & Magliano, 2009), and bundling texts provides opportunities for students to build knowledge upon a foundation. In addition, bundling texts can increase the goal-oriented nature of reading and lead to deeper cohesion and integration of knowledge across texts. Third, tools on the iPad, such as highlighting and note taking, could encourage active processing and thinking while reading on the iPad. Highlighted portions of texts and notes could also be discussed with a peer group increasing the interactive and social benefits of reading. Fourth, many students may benefit from explicit instruction and modeling around the use of hyperlinks. In providing students with more purposeful guidance around the use of hyperlinks, developing readers can be given the advantage of multimodal learning. It is an important goal in schools today to differentiate comprehension instruction for the needs of individual students (Duke & Carlisle, 2011), and the iPad can potentially support this initiative.

Our data demonstrates the use of iPads in classrooms increases the critical role of teachers in planning learning experiences for students. It is important that schools build the capacity of both students and teachers for best using these tools. Information is needed to inform best practice based on student need and context of the classroom. In our study, the role of the teacher was less important for secure readers who connected background knowledge with the text, built a coherent representation of text while reading, and took advantage of hyperlinks to learn more about anything that was confusing. The role of the teacher was critical for developing readers in order to scaffold the acquisition of science content from text read on an iPad. As we have found, teachers' purposeful planning and instruction become even more important for developing readers in a world of new literacies.

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