How Do Elementary Teachers Study and Learn from a Multimedia Model of Reading Development? An Exploratory Eye-Tracking Study

Pamela Beach
Queen's University

John Kirby
Queen's University

Pamela McDonald
Queen's University

Jen McConnel
Queen's University

Canadian Journal of Education / Revue canadienne de l'éducation 42:4 (2019)

www.cje-rce.ca

Abstract

This exploratory study used eye-tracking methodology to examine how elementary teachers study a multimedia model of reading development. Seven experienced teachers and 11 pre-service teachers participated. Visual attention, prior knowledge, and post-task scores were analyzed using quantitative and qualitative methods. Significant differences between the two groups were found with respect to fixations, scan paths, and pre- and post-task scores. Where experienced teachers focus their attention and the paths of their visual behaviour can inform the design of material that supports novice teachers' understanding of how children learn to read.

Keywords: teacher learning, multimedia learning, eye-tracking methodology, reading development, reading instruction

Résumé

Cette étude exploratoire a utilisé une méthodologie de suivi du regard pour examiner comment les enseignants du primaire étudient un modèle multimédia de développement de la lecture. Sept enseignants expérimentés et 11 enseignants débutants ont participé. L'attention visuelle, les connaissances préalables et les résultats postérieurs à la tâche ont été analysés à l'aide de méthodes quantitatives et qualitatives. Des différences significatives entre les deux groupes ont été constatées en ce qui concerne les fixations, les chemins d'analyse et les résultats avant et après la tâche. Là où des enseignants expérimentés concentrent leur attention ou leur regarde peuvent influencer le développement des matériaux pour aider les enseignants débutants à mieux comprendre comment les enfants apprennent à lire.

Mots-clés : apprentissage de l'enseignant, modèle multimedia, attention visuelle, développement de la lecture, instruction de la lecture

Introduction

Learning opportunities for teachers, whether face to face or online, often include different types of multimedia, such as video, text, images, diagrams, sound, and animation. Of concern is the limited research available on the validity and value of multimedia learning resources for enhancing teacher knowledge and practice in reading instruction. Methods such as interviews and surveys can offer information about how teachers view their learning. These self-reported measures, however, are limited to participants' recollection of past events and affected by the social desirability of responses, and do not capture the moment-to-moment variations in cognitive processes (Alemdag & Cagiltay, 2018). As such, it is important to obtain data about teachers' behavioural patterns and thought processes *during* learning without any interruptions; interrupting learners to ask them what they are doing and why may severely alter what they do. One method that can avoid the limitations of self-reporting measures and document cognitive processes that occur during learning is eye tracking (Beach & McConnel, 2019; Desjarlais, 2017; Johnson & Mayer, 2012).

The use of eye-tracking methodology to study teacher learning has the potential to generate comprehensive data about teachers' learning processes, which, in turn, can contribute to more effective instructional approaches and learning support tools. Eye-tracking methodology is based on the assumption that there is a correlation between how long something is fixated and how long it is processed (Just & Carpenter, 1980). The argument is that visual attention and cognitive processing occur almost simultaneously so that information is perceived and processed at a cognitive level (Scheiter & Eitel, 2017). In eye-tracking research, measures of visual attention include fixation counts (the number of times fixations are directed toward a specific area known as the "area of interest" or AOI), fixation duration (sustained attention of an AOI), and patterns of saccades (scan paths). Educational research using eye-tracking technology has shown that fixations—including duration, frequency, location, and sequence—are meaningful measures for understanding learning behaviours and processes (Desjarlais, 2017).

Current Study

This exploratory study used eye-tracking methodology to investigate the patterns of visual behaviour and cognitive processes of experienced elementary teachers and pre-service teachers in an initial teacher education program while they studied a visual model called the "Reading Pyramid," which shows key concepts in reading development and instruction (Ontario Institute for Studies in Education [OISE], 2012). The key components highlighted in the Reading Pyramid are essential to every beginning reading program (August & Shanahan, 2006; Castles, Rastle, & Nation, 2018; Graham, McKeown, Kiuhara, & Harris, 2012; Hjetland, Brinchmann, Scherer, & Melby-Lervåg, 2017) and include phonological awareness, alphabet knowledge and phonics, morphological awareness, word recognition, reading fluency, vocabulary development, and reading comprehension strategies. Similar to *The Cognitive Foundations of Learning to Read Framework* (Wren, 2000), the Reading Pyramid illustrates the building blocks of reading by organizing these components into two main groups—print-related skills (those that promote the ability to recognize words) and language-related skills (those that support the ability to make meaning of text). In combination with accompanying text, the Reading Pyramid appears on a professional development multimedia website called the Balanced Literacy Diet: Putting Research into Practice in the Classroom (http://www.litdiet.org). This website uses the metaphor of a healthy diet to provide a context for teachers to understand how the various components of reading development (the "food groups," according to the healthy diet framework) work together to support reading comprehension (OISE, 2012).

Research shows that combining presentation modes can greatly enhance learning (e.g., Kennedy, Driver, Pullen, Ely, & Cole, 2013; Kennedy & Thomas, 2012; Moreno & Mayer, 2007); however, research that tracks teachers' visual behaviours and cognitive processes as they use multimedia is limited (Beach & McConnel, 2019). Moreover, studies that examine the impact of teachers' prior knowledge on multimedia learning and whether particular patterns of behaviour during multimedia learning lead to enhanced knowledge are rare. Given these gaps in the literature and the call for more studies to use eye-tracking technology to track moment-to-moment processes that occur during learning (Desjarlais, 2017; Scheiter & Eitel, 2017), the current study seeks to shed light on our understanding of the effective use of multimedia learning tools by elementary teachers. Therefore, the three primary objectives of this study are to (1) determine elementary teachers' learning patterns and processes as they study the Reading Pyramid and accompanying text, (2) examine the extent to which elementary teachers learn from the Reading Pyramid and accompanying text, and (3) determine the extent to which elementary teachers' learning patterns and processes are related to what they learn. A secondary goal of this study is to offer information about how eye-tracking methodology can be used to study teacher learning.

Literature Review

Components of Effective Reading Programs

Stemming from Hoover and Gough's (1990) simple view of reading, reading skills can be organized into two main groups: decoding and linguistic comprehension. Decoding skills are those that promote the ability to recognize words, while linguistic comprehension encompasses language-related skills that support the ability to make meaning of text. According to the simple view of reading, both sets of skills contribute jointly to reading comprehension. As the name implies, the simple view of reading provides a relatively straightforward way of understanding the complexities of reading. As a result, a framework outlining the cognitive foundations of learning to read was developed to give teachers access to the relevant research, and to support teachers' understanding of the print- and language-related skills involved in reading development and how these skills contribute to reading comprehension (Wren, 2000). The Reading Pyramid is a similar visual representation illustrating how the building blocks of reading comprehension can be divided into print-related skills (e.g., concepts of print, phonics, alphabetic principles) and language-related skills (e.g., phonemic awareness, vocabulary, background knowledge).

Professional learning in reading instruction. Research shows a positive relationship between teachers' knowledge of the foundational reading skills outlined above and student outcomes in reading (Cash, Cabell, Hamre, DeCoster, & Pianta, 2015; Cunningham, Zibulsky, Stanovich, & Stanovich, 2009; Moats & Foorman, 2003; Piasta, Justice, McGinty, & Kaderavek, 2012). Several studies have found that teachers who receive professional development in reading instruction based on the aforementioned reading skills have students who perform significantly better on reading-related tasks than students whose teachers did not receive the same type of information (e.g., Carlisle, Kelcey, Rowan, & Phelps, 2011; Ottley et al., 2015; Piasta et al., 2012; McCutchen et al., 2002; Moats & Foorman, 2003).

More recent studies examining teacher learning in the context of reading development and instruction have documented how digital technology and multimedia are viewed as effective and engaging approaches for enhancing teacher learning (e.g., Hughes, Liu, & Lim, 2016; Zottmann et al., 2013). For instance, studies that have examined the impact of video on teacher engagement have found that shared video viewing between an instructor and education students engages pre-service teachers in the learning process and enhances their pedagogical knowledge (Gaudin & Chaliès, 2015; Sherin & Russ, 2014). Similarly, in a study that investigated the role of virtual classroom environments in literacy education coursework, findings suggested that virtual classrooms showcasing effective literacy practices provide novice teachers with an additional venue for learning about instructional practices in reading (Beach, Martinussen, Poliszczuk, & Willows, 2018). Additionally, the use of podcasts (Ely, Kennedy, Pullen, Williams, & Hirsch, 2014), online modules (Martinussen, Ferrari, Aitken, & Willows, 2015), and social media (Visser, Evering, & Barrett, 2014) in teacher education programs and professional development have been explored in recent years. These studies suggest that learning through multiple modes of information can lead to increased engagement with domain-specific content. However, we do not yet have a comprehensive understanding of the learning behaviours and processes that may or may not be occurring during teachers' multimedia learning. Furthermore, research has not yet evaluated whether elementary teachers actually learn from multimedia resources and can apply their learning to practice.

This study includes both pre-service and experienced elementary teachers to examine differences in learning from multimedia based on teaching experience and knowledge about reading development and instruction. Novice–expert studies show what the results of successful learning might look like; experienced teachers have acquired skills and knowledge that affect "what they notice and how they organize, represent, and interpret information" (National Research Council, 2000, p. 31). Examining how teachers at different stages of their career use multimedia resources and where they focus their attention can inform the design of material that supports teachers' understanding of how children learn to read.

Theoretical Framework: Multimedia Learning

Multimedia learning is an active process of understanding information presented in more than one mode. During multimedia learning knowledge is constructed from words (spoken or printed text) and pictures (static graphics, including illustrations and photos, or dynamic graphics, including video; Mayer, 2014). The rationale is that people learn more deeply from the combination of words and pictures than from words alone, and that they do this by constructing a coherent mental representation from the presented material (Mayer, 2014; Schnotz, 2014).

The cognitive theory of multimedia learning forms the basis of this rationale (Mayer, 1997). Composed of three assumptions—dual-channel, limited-capacity, and active processing—this theory is used to help explain how learners process visual and verbal information (Mayer, 1997). Grounded in Paivio's (1986) dual coding theory, the dual-channel assumption suggests that humans process visual and auditory information via two separate channels. The second assumption is based on Sweller's (1998) cognitive load theory and implies a limited amount of information that can be processed at a time. Thirdly, the cognitive theory of multimedia learning assumes that humans actively select, organize, and integrate incoming information to construct coherent mental representations (Mayer, 2014). Individuals first attend to relevant elements in the multimedia material (Mayer, 2014). This selection process forms the basis for the most relevant information and is dependent on the task and learning goals. Organization of information occurs when individuals make connections between units within the material, including the amount of time spent fixating on material, and identify levels of importance. Finally, information from textual and pictorial elements is integrated when transitions between two segments of information occur. The integration of verbal and pictorial models has been suggested to be the most critical step in multimedia learning for sense-making (Mayer, 2014).

A goal of the cognitive theory of multimedia learning in education is to understand how to design environments that promote meaningful learning (Moreno & Mayer, 2007). Several studies have shown how the combination of presentation modes can greatly enhance learning (e.g., Kennedy et al., 2013; Kennedy & Thomas, 2012; Moreno

& Mayer, 2007). For instance, a frequently cited study by Mayer, Bove, Bryman, Mars, & Tapangco (1996) found that college students who read a summary that contained a combination of short captions and illustrations outperformed those who read the summary with text alone in transfer and retention tasks. Similarly, Chiou, Tien, and Lee (2015) found that the combination of animation and concept maps contributed to greater learning than did concept maps alone. In the context of teacher learning, Ely and colleagues (2014) used a multimedia learning tool that combined video viewing with still images and on-screen text and audio to teach vocabulary practices to pre-service teachers. Results indicated that pre-service teachers in the multimedia group demonstrated significantly greater increases in knowledge and readiness to implement an evidence-based instructional practice than those who did not receive the multimedia presentation.

While these studies demonstrate that the combination of presentation modes can lead to enhanced learning, simply combining modes of information does not guarantee improvement in learning; "a specific media application may not significantly change learning effectiveness (how well the medium can be used in instruction)" (LeeSing & Miles, 1999, p. 212). For instance, the addition of interesting but irrelevant material to a narrated animation may actually distract the learner, who will then become less engaged with the relevant material (e.g., Scheiter & Eitel, 2017). Distracting information is likely to contribute to an increase in cognitive load, "the level of mental energy required to process a given amount of information" (Lim, 2004, p. 17). As a result of a higher cognitive load, task performance and learning may be compromised.

Eye tracking and multimedia learning. The number of studies that have used eye tracking to study multimedia learning is relatively low (Alemdag & Cagiltay, 2018). Yet eye-tracking technology has long enabled researchers to make inferences about how learners process information in different formats (Alemdag & Cagiltay, 2018). Eye movement measurements can reveal visual attention on items in a scene, change in the focus of visual attention, difficulty in processing, and depth of processing information (Alemdag & Cagiltay, 2018; Lai et al., 2013). In their review of 58 of the most recent studies that have used eye-tracking technology to study multimedia learning, Alemdag and Cagiltay (2018) found that several studies made inferences about depth of processing from fixation measurements. Rayner (1998) also argued that longer fixations can indicate deeper processing.

Alemdag and Cagiltay (2018) also found that scan paths were often used to determine learners' sequence of attention during organization of words or images. Learners often integrate text and pictorial information (they build a mental model) either locally, by switching their eyes between text and illustration, or globally, by gazing at most or all of the components of the illustration after reading the text (Hegarty & Just, 1993; Liu, 2018). Local patterns of integration have been shown to precede global ones (Hegarty & Just, 1993). Most important is the relevance of the two modes of information—transitions between semantically related material are often associated with higher learning outcomes (Alemdag & Cagiltay, 2018).

Based on the current literature, employing eye tracking to document moment-to-moment processes that occur during learning has the potential to generate information about teachers' learning processes that cannot otherwise be articulated by participants. Generating this information is integral to the study of teacher learning and an essential step in the development of effective resources and learning tools that support teachers in their understanding of how reading develops and can best be taught.

Study Purpose and Research Questions

The purpose of this study was to investigate the patterns of visual behaviour and cognitive processes of experienced elementary teachers and pre-service teachers in an initial teacher education program while they studied the Reading Pyramid, a visual model showing key concepts in reading development, and accompanying text (OISE, 2012; see Figure 1). The following research questions guided this study's research design and analyses:

1. What are pre-service and experienced teachers' eye movement patterns as they study the Reading Pyramid and accompanying text?
2. To what extent do elementary teachers' eye movement patterns differ according to teaching experience and knowledge of reading development?
3. Do particular eye movement patterns affect what elementary teachers learn?

Methodology

Research Design and Participants

The study design includes both quantitative and qualitative components, with the eye-tracking metrics and recordings as the main data sources (as described below). Approximately 60 students from a concurrent Bachelor of Education program at a Canadian university were invited to participate via email invitations and course visits. Approximately 150 teachers with experience teaching at the elementary level were also sent an email invitation to participate. Email invitations described the research project and participant involvement.

Seven experienced teachers and 11 education students from Ontario, Canada, participated in this exploratory study ($N = 18$). Experienced teachers had between 2 and 10 years of experience. Most of the students ($n = 10$; 91%) had completed at least one field placement in a primary classroom. More than half of the participants ($n = 12$; 67%) stated they use the Internet to acquire information about reading development and/or instruction and all of the participants indicated that they feel somewhat confident ($n = 7$; 39%) or very confident ($n = 11$; 61%) using the Internet to acquire information related to their teaching practice. All participants provided informed consent.

Data Collection Procedure

Participants met one-on-one with a member of the research team for a testing session. During the testing session, participants completed three tasks: (1) a short demographic questionnaire and test of literacy knowledge, (2) a cognitive task that included a study session in which participants' eye movements were recorded, and (3) a summary task. Upon completion of the questionnaire and test of literacy knowledge, participants were introduced to the cognitive task and eye-tracking technology. Specifically, participants were asked to study the graphic and textual information while thinking about how the literacy components of the Reading Pyramid work together to support children's reading development. Participants were not given a time limit during the study session; rather, they were free to study the graphic and textual information for as long as they required.

Immediately following the cognitive task, participants were asked to complete a summary task that included a transfer and retention test.

Data Sources and Material

Demographic questionnaire. The questionnaire consisted of five closed-ended questions: (1) Are you currently a student or teacher? (2) How many years have you taught at the elementary level (for experienced teachers)? (3) How many placements have you had in an elementary classroom (for pre-service teachers)? (4) How often do you use the Internet to acquire information about reading development and/or instruction? (5) How confident are you in using the Internet to acquire information about teaching?

Test of literacy knowledge. Ten items were adapted from two main instruments for assessing teacher knowledge of literacy (Cheesman, McGuire, Shankweiler, & Coyne, 2009; Duguay, Kenyon, Haynes, August, & Yanosky, 2016). Five questions were multiple choice (e.g., Effective phonemic awareness instruction teaches children to (a) convert letters or letter combinations into sounds; (b) notice, think about, and work with sounds in spoken language; (c) discriminate one letter from the other letters of the alphabet; or (d) I'm not sure), three were true/false (e.g., Students do not benefit from vocabulary instruction that activates their background knowledge. T/F), and two were sentence completion (e.g., Reading comprehension is __________).

Stimulus. The stimulus included two panels: the visual model (the Reading Pyramid) and accompanying textual information (see Figure 1).

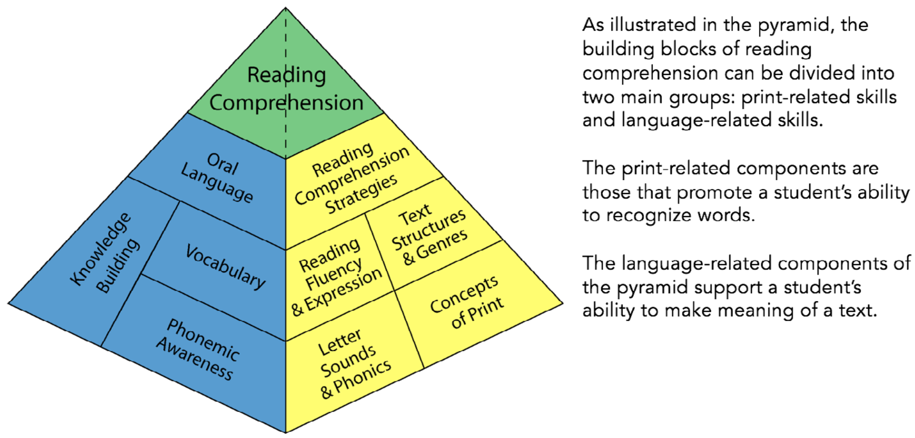

Figure 1. The Reading Pyramid and accompanying text

Eye-tracking recordings. Participants' eye movements were recorded using a Tobii Pro X3-120 eye tracker, a screen-based eye tracker that captures gaze data at 120Hz. The Tobii eye tracker works by using a light source to illuminate the eye, causing highly visible reflections. A camera captures an image of the eye showing these reflections. Prior to studying the stimulus, participants were taken through a calibration procedure: participants looked at five specific points on the screen, known as calibration dots. The resulting information helped calculate the gaze data necessary for the eye movements to be recorded.

Eye-tracking metrics. Using the Tobii Pro Studio software, areas of interest (AOIs) on the pyramid and keywords in the text were predetermined. Each pyramid block was designated as a separate AOI. The following keywords in the text were also AOIs: "pyramid," "building blocks," "print-related skills," "language-related skills," "print-related components," "recognize words," "language-related components," "make meaning of text." Variables of interest included: fixation duration, frequency and sequence of fixations, and scan paths. A fixation duration was included in the dataset for gaze durations of 60 ms or longer (the default value set by Tobii Pro Studio). The total recording time (in seconds) for each participant was recorded as the duration from the time that the stimulus appeared on the screen until the time the participant indicated their completion of the task. The total recording time includes the time participants spent fixated on any of the AOIs plus any time they spent on other areas of the display.

Heat maps. Heat maps visually represent fixation duration and were used to support the statistical results.

Summary task. Immediately following the cognitive task, participants completed a summary task which was composed of a transfer and retention task. Resulting verbalizations from both the retention and transfer tasks were audio recorded and transcribed verbatim.

Transfer task. Participants were asked to verbalize how they would explain the basics of teaching reading to someone new to teaching at the elementary level. Participants verbalized their explanation without access to the stimulus.

Retention task. The retention test included two questions: (1) Please describe the reading pyramid. (2) While you studied the reading pyramid, what stood out to you?

Scoring

Three members of the research team used a rubric to score participants' transfer and retention tasks. Scores were based on whether participants included pre-determined themes, main ideas, and/or important details in their responses (following the guidelines of Kirby & Pedwell, 1991). Each category included subcategories. Participants who referred to a theme in their response (e.g., the ultimate goal of reading is to help students understand the meaning of what they are reading) received a score of 3; a main idea (e.g., print skills are those that promote word recognition) received a score of 2; and an important detail (e.g., associate letters and sounds) received a score of 1. Scores were averaged across the researchers and total scores on the transfer and retention tasks were calculated for each participant. To determine inter-rater reliability, intraclass correlation coefficient (ICC) estimates and their 95% confidence intervals (CI) were calculated based on absolute agreement and a two-way mixed-effects model. A high degree of reliability was found between the three raters. The average measure ICC was .886 with a 95% CI from .645 to .962.

Analysis

Paired-samples *t*-tests and independent-samples *t*-tests were conducted, with alpha set at $p < .05$, to examine group differences in fixation duration, fixation count, and summary task scores. Pearson correlations were also computed to determine relationships between measures of visual attention on AOIs of the pyramid, measures of visual attention on keywords in the accompanying text, and summary task scores. Eye movement recordings were also analyzed qualitatively to determine the correspondence between AOIs on the pyramid and keywords in the text when participants transitioned between the two panels of the stimulus display. This qualitative analysis was conducted by two members of the research team through observations of the eye-tracking recordings.

Results

This exploratory study sought to examine the patterns of visual behaviour and cognitive processes of experienced elementary teachers and pre-service teachers in an initial teacher education program while they studied a multimedia learning tool. Results are organized according to the research questions.

Research Question 1: What are pre-service and experienced teachers' eye movement patterns as they study the Reading Pyramid and accompanying text?

A paired-samples *t*-test between fixation durations on the AOIs of the pyramid and keywords in the text showed that, on average, both groups spent significantly more time fixated on AOIs of the pyramid ($M = 46.64$ seconds, $SD = 31.18$) than keywords in the text ($M = 12.03$, $SD = 8.01$); $t(17) = 5.27$, $p < .001$. Figure 2 presents two individual heat maps, one from each group, to illustrate this finding: participants fixated longer (represented by red shadings) on AOIs of the pyramid than on keywords in the accompanying text. Both groups also fixated longer on the AOIs related to print-related skills ($M = 23.27$ seconds, $SD = 17.82$) than the AOIs related to language-related skills ($M = 13.56$ seconds, $SD = 8.67$); $t(17) = 3.97$, $p = .001$. Taken together, these findings indicate that participants were more likely to attend to the Pyramid, and specifically the print-related AOIs, while thinking about how the different literacy components work together to support children's reading development.

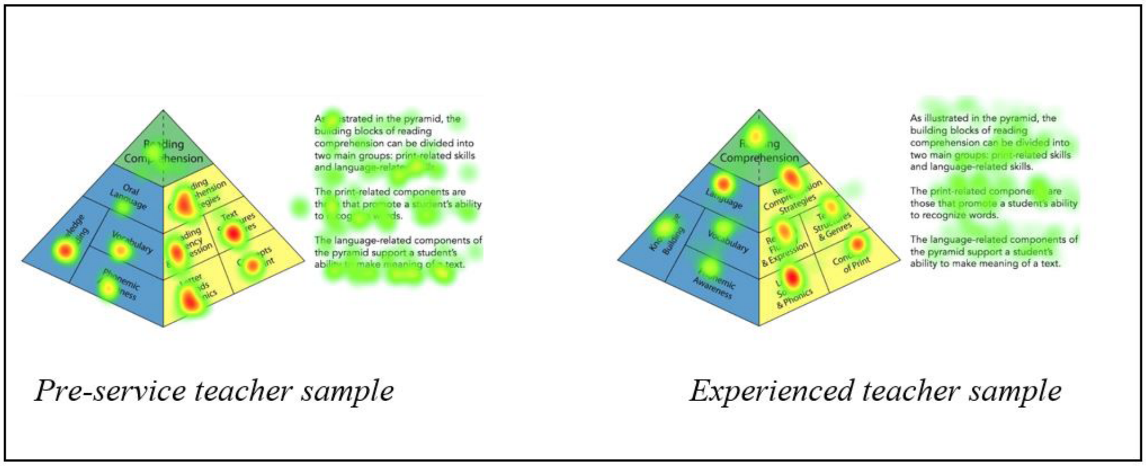

Figure 2. Sample heat maps depicting fixation duration
Note. Red shading indicates longer fixation duration.

With respect to the total recording time (in seconds), group differences were found: the average total recording time for experienced teachers (M = 127.29 seconds, SD = 57.49) was higher than for the pre-service teachers (M = 94.09 seconds, SD = 31.39); however, the independent samples t-test did not yield a significant effect, $t(16) = 1.59$, $p = .131$. In terms of fixation duration and fixation count on AOIs of the Pyramid, significant effects were found: the experienced teachers fixated significantly longer on the Pyramid (M = 64.29 seconds, SD = 35.10, $t(16) = 2.26$, $p = .039$) and looked at the Pyramid more frequently (M = 254.29, SD = 138.10, $t(16) = 2.19$, $p = .044$) than the pre-service teachers (fixation duration: M = 33.77 seconds, SD = 22.70; fixation count: M = 144.72; SD = 75.80). A summary of the descriptive statistics regarding group differences is presented in Appendix A.

Appendix B presents the descriptive statistics regarding fixation counts and fixation durations on the AOIs of the Pyramid. Given that this is an exploratory study, it is important to note that all of the effects are in favour of the experienced teacher participants and that many of the effect sizes are substantial even if they are not significant. The longer fixation durations suggest, as discussed below, that the experienced teachers processed information from the Pyramid at a deeper level than the pre-service teachers.

Pearson correlations showed that participants who fixated longer on print-related AOIs on the Pyramid spent more time fixated on the print-related keywords in the accompanying text ($r = .48$, $p < .05$). Fixation duration for language-related AOIs was also positively correlated to fixation duration for language-related keywords in the accompanying text ($r = .64$, $p < .01$). One possible reason for this finding, as discussed below, is that participants made connections between specific information on the Pyramid (e.g., phonics) and semantically related keywords (e.g., "recognize words").

Research Question 2: To what extent do elementary teachers' eye movement patterns differ according to teaching experience and knowledge of reading development?

As shown in Appendix C, significant differences were found in knowledge of reading development between the two groups. This finding is not surprising, given pre-service teachers had limited coursework in literacy as well as classroom experience.

Correlations between participants' literacy knowledge and fixation counts and duration are presented in Appendix D. Findings suggest that prior knowledge and experience influenced how participants viewed the Reading Pyramid and accompanying text. For instance, knowledge of phonemic awareness instruction was correlated with participants' fixation count on AOIs of the Reading Pyramid related to phonics ($r = 0.51$, $p = 0.031$) and concepts of print ($r = 0.56$, $p = 0.016$).

Observations of participants' scan paths were documented by members of the research team. Based on these observations, participants' scan paths were classified as: local integrative pattern (eye movements transitioned between the Pyramid and semantically related keywords), global integrative pattern (eye movements transitioned to the Pyramid after gazing at most or all of the text), and inconsistent skimming pattern (unrelated transitions between the Pyramid and text). Figure 3 illustrates typical scan path diagrams of each of these types of patterns.

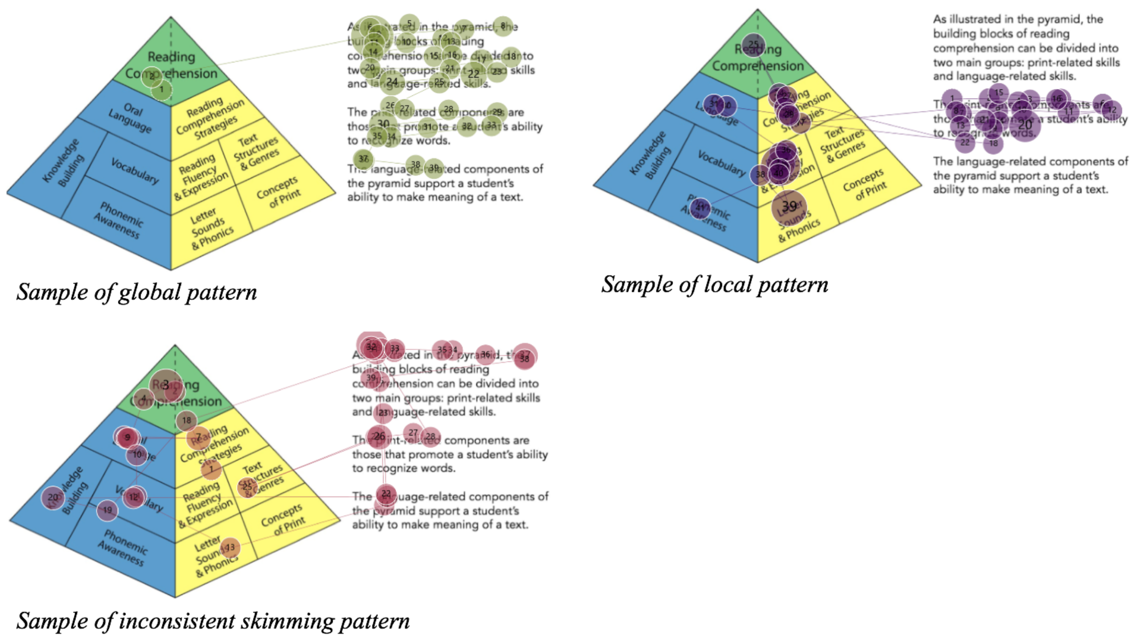

Figure 3. Typical scan path diagrams of three types of patterns of visual behaviour

The qualitative analysis of the scan paths revealed that the more experienced teachers (who scored significantly higher on the test of literacy knowledge) tended to move back and forth between information in the Pyramid and semantically related keywords. This pattern of behaviour, a local integrative pattern according to Hegarty and Just (1993), occurred for nearly all of the experienced teachers (*n* = 6; 86%). The one experienced teacher who did not demonstrate this type of scan path instead showed a more global integrative pattern in which this teacher read through the entire text before looking at the Pyramid. This initial global pattern was followed by a local integrative pattern. The pre-service teachers, on the other hand, demonstrated three different patterns of visual behaviour: six of the pre-service teachers (55%) demonstrated an inconsistent skimming pattern, four (36%) demonstrated a global integrative pattern (text then Pyramid), and one pre-service teacher showed a local integrative pattern of moving back and forth between semantically related material. The pre-service teacher who showed a local integration pattern did not score significantly higher on the pre-test of literacy knowledge or the post-test than the other pre-service teachers.

Research Question 3: Do particular eye movement patterns affect what elementary teachers learn?

Results also show group differences between the two groups with respect to the summary task scores. On average, experienced teachers scored higher on both the transfer task ($M = 6.86$, $SD = 3.13$) and retention task ($M = 9.71$, $SD = 3.82$) than the pre-service teachers (transfer task: $M = 4.55$, $SD = 1.97$; retention task: $M = 6.09$, $SD = 2.47$); however, the independent samples t-test only yielded a significant effect for the retention task scores, $t = 2.46$, $p = .026$. A more interesting finding relates to the correlations between measures of visual attention and summary task scores for all participants. Findings show that the time spent on two specific AOIs correlated with participants' post-task scores (see Appendix E): a positive correlation was found between scores on the retention task and fixation durations on the vocabulary AOI of the Pyramid ($r = .55$, $p < .05$) and the phonics AOI of the Pyramid ($r = .52$, $p < .05$). The correlations for the transfer task, although some were moderate in size, did not reach the conventional level of significance.

Discussion

In the current study, we examined the role of a multimedia resource on teacher learning. Overall, findings provide preliminary insights into how elementary teachers at different stages of their career study and learn from a multimedia learning tool that supports reading development and instruction. Additionally, results offer information about the benefits of using eye-tracking methodology to study teacher learning.

First, the findings provide preliminary insights into how elementary teachers at different stages of their career study the Reading Pyramid, a multimedia learning tool created to enhance teacher knowledge in reading development instruction. The use of multimedia in teacher education and professional learning is increasing (Kennedy et al., 2013). Yet the evidence for the effectiveness of multimedia resources is limited. As suggested by Kennedy and colleagues (2013), there is a "critical need to improve the knowledge of reading and reading instruction among pre- and in-service teachers" (p. 49). As new multimedia tools and technologies are adopted by teacher educators and educational stakeholders involved in developing online learning platforms for teachers, they should be accompanied by efforts to study the use of such resources and their impact on learning.

The finding that participants generally had longer and more fixations on the AOIs of the Pyramid than on keywords in the accompanying text suggests that the Pyramid is visually engaging. In relation to the total recording time, the fixation durations appear relatively short. However, our results do align with studies that have examined the shortest length of time it takes individuals to acquire semantic information from a web page (Jahanian, Keshvari, & Rosenholtz, 2018; Lindgaard, Fernandes, Dudek, & Brown, 2006); for example, Jahanian and colleagues (2018) demonstrated that in a 120ms fixation, individuals can categorize information. The average time that participants fixated on AOIs of the Pyramid suggests that the information was processed at a semantic level.

The correlation between the retention task scores and specific AOIs in the Pyramid suggests that the Pyramid is also informative—time spent on specific AOIs was positively correlated to participants' scores on the retention task, suggesting that some of the Pyramid components may have positively influenced participants' recall of the Pyramid, specifically in relation to the main ideas and overall theme. Responses given by the participants during the summary task support this interpretation. For instance, an experienced teacher participant stated that the Pyramid was "a nice visual for understanding cognitively what we need to get through in order for comprehension to be a skill for kids." One of the pre-service teachers noted: "I liked how [the Pyramid] had the different faces of spoken and written text coming together at the top to combine into one's reading comprehension." Similarly, a pre-service teacher participant described the connection between the reading Pyramid and coursework: "It all makes sense and corresponds with what I've learned so far in my teaching schools and practicums and classes."

This finding, however, is in contrast with Liu and Chuang (2011) among others (e.g., Rayner, Rotello, Stewart, Keir, & Duffy, 2001; Schmidt-Weigand, Kohnert, & Glowalla, 2010), who have shown that learners spend more time on text than on illustrations. One possible reason for this difference is that the participants in the current study were taking more time to make sense of the structure of the Pyramid—how the blocks were organized and related to each other. Several participants noted in the summary task how the organization of the Pyramid stood out to them. One participant noted that she tried to approach the Pyramid in a few different ways (e.g., starting at the bottom and working her way up, reading all of the print-related components) to understand how the parts related to the whole. It is possible that the complexity and novelty of the Pyramid required more time to make sense of than the media used in Liu and Chuang's study. It is also possible that the AOIs for the keywords were too narrow and did not capture all of the current study participants' actual fixations on the keywords in the text. Another possibility is that the text did not provide enough information to require much attention. This is further discussed in the Limitations section.

While participants generally spent more time studying the Pyramid than the keywords in the accompanying text, an interesting finding is that the experienced teachers transitioned between the two modes of information more often than the pre-service teachers, and also showed a pattern of visual behaviour in which their eyes moved between information in the Pyramid that directly corresponded with related keywords in the text. As previous studies have found, when the text and picture present consistent information (when the information is semantically related) it is more likely that both modes of information are simultaneously active in working memory (e.g., Schnotz, Baadte, Johnson, & Mengelkamp, 2012). Jarodzka, Scheiter, Gerjets, and van Gog (2010) also found that when compared to novices, experts attended to more relevant aspects of a stimulus. In the current study, it is possible that the experienced teachers were connecting the central definitions of the print- and language-related categories to the more specific components of each category. Their prior knowledge may have contributed to a stronger connection between the information in the Pyramid and corresponding text than for the pre-service teachers, and a more integrative visual pattern of behaviour (Hegarty & Just, 1993; Liu, 2018). This behavioural pattern was described by one experienced teacher during the summary task:

> I would read part of the definition that explained the language side of literacy, and then I would go and look at that part of the pyramid again, and then I would read the print side and then go back to that part of the pyramid again.

This finding also relates to the cognitive theory of multimedia learning. The experienced teachers in this study were able to actively select, organize, and integrate incoming information, and therefore were more likely to construct a coherent mental representation of reading development and instruction; they made connections between the presented material. As outlined by Mayer's (1997, 2014) theory, information from textual and pictorial elements is integrated when transitions between two segments of information occur. Given their prior knowledge, the experienced teachers who were exhibiting a local pattern of behaviour were more likely able to reach an "integration stage," the most critical step in multimedia learning for sense-making and deeper levels of processing (Mayer, 2014).

These deep levels of processing include linking information to prior knowledge, interpreting information, and connecting new information to personal experiences (Catrysse, Gijbels, & Donche, 2018). An individual's interest in and prior experience with the material can impact the level of processing. The participants with higher levels of prior knowledge about reading development and more teaching experience may have had a greater interest in the presented material and thus showed a deeper level of information processing. These participants engaged with the material in ways that are associated with deeper processing (local integration pathways, longer fixations), and subsequently demonstrated higher scores on the retention task, in which greater recall of main ideas and elaborations and coherence of main ideas are all evidence for more developed situation models.

The results of this study also highlight the importance of using diverse methods to understand how teachers learn in different contexts and with different forms of media. Diverse methods of data collection are necessary to fully understand and capture how teachers learn, the reasons why they choose specific modes of learning, and the potential impact of learning opportunities on teachers' knowledge and skills. Data generated from eye-tracking methodology has the potential to provide important information about teachers' behavioural patterns and cognitive processes that may or may not be occurring during multimedia learning experiences. In particular, findings from the current study suggest that fixation durations and scan paths can be particularly important for identifying eye movement patterns that are conducive to learning. Information pertaining to the processes of selecting, organizing, and integrating can be garnered from examining teachers' eye movement patterns. While eye tracking alone can offer insight into the processes that occur during learning, combining eye tracking with other methods of data collection, such as the think-aloud method and pre-post task scores, can result in comprehensive data about how teachers use and learn from multimedia resources. For instance, eye tracking can show automatic processing that may escape conscious awareness and think alouds can offer insight into learners' decision-making strategies that may not involve eye movements.

Study Limitations

A main limitation of this study is the sample size, which influenced the overall power of the study to detect significant results. While this limitation is not uncommon in eye-tracking studies that examine differences between expert and novice participants (Jarodzka et al., 2010), the small sample size should be taken into consideration when interpreting the findings. Along with the sample size, participants' teaching experience should also be considered when interpreting the results. Future studies should consider recruiting teachers who have a greater range of experience teaching reading. An additional limitation is the validity of the transfer task. Given that this study was exploratory in nature, the transfer task was piloted for this study.

A final limitation involves the fixations on keywords in the text. As described in the discussion section, it is possible that the AOIs for the keywords were too narrow and did not capture all of the participants' actual fixations on the keywords in the text. This is particularly true if the calibration accuracy was low. The scan paths did reveal, however, that participants were demonstrating patterns of line-by-line reading behaviour. Additionally, the text used for this study was short. The results might differ if the text and diagram explained a more complex process at greater length. Future research should consider enlarging text to allow for larger AOIs on keywords and using more extensive and complex material.

Implications for Teacher Learning

Despite the limitations, there are educational implications that can be gleaned from the results, particularly with respect to how the experienced teacher participants studied the Reading Pyramid. Experienced teachers can provide information about what successful learning might look like; they have acquired skills and knowledge that affect "what they notice and how they organize, represent, and interpret information" (National Research Council, 2000, p. 31). Examining how teachers at different stages of their career use multimedia resources and where they focus their attention can inform the design of materials so that resources facilitate more efficient inspection.

In the current study the paths of the experienced teachers' eye movements revealed a direct correspondence between areas of the Pyramid and semantically-related keywords. These scan paths can be used with novice or pre-service teachers. Specifically, novice teachers may benefit from instruction in the form of online learning support tools or tutorials that contain "attentional guidance" in order to recognize the parts of the text and Pyramid that directly align. A form of cueing by guiding novices' attention based on experts' eye movements might be effective (Jarodzka et al., 2010) and should be tested.

Given the findings, it can be suggested that students should have developed some prior knowledge about the key areas of reading development and instruction prior to studying the Reading Pyramid in a teacher preparation course. Teacher educators should also provide guidance on the structure and organization of the Reading Pyramid when introducing it to students; this guidance would be consistent with the guidelines for developing a good situation model. In online environments, an interactive component in which viewers hover over selected areas of the Pyramid to view detailed information about a particular area could also contribute to deeper levels of processing.

Showing novice teachers slowed-down scan paths of experienced teachers' eye movements prior to studying the Reading Pyramid or similar multimedia should be further examined. It is possible that scan paths of experienced teachers can act as a model for a successful way to approach and learn from the reading pyramid. Teacher educators could include cueing videos as additional support tools for their students. Cueing videos could also be embedded within online learning platforms. Users of online professional resources could access these videos to support them in their self-directed learning initiatives.

Conclusion

As teachers increasingly access multimedia resources as part of their multifaceted approach to professional learning, the value of such resources must be examined. It is essential to understand and capture teachers' behavioural patterns and thought processes in order to facilitate the design of effective training and learning platforms. In this study, the group differences in fixation counts, fixation durations, and scan paths suggest that teachers study multimedia in different ways depending on their prior knowledge and experience. Website developers and instructional multimedia designers can use information generated from studies that employ eye-tracking methodology to facilitate more efficient inspection. This information can be used as learning support tools, to scaffold and improve novice teachers' understanding of reading development and instruction. Multimedia resources that are conducive to teacher learning will lead to teachers being more skilled in reading instruction and ultimately contribute to improvements of reading ability in their students.

References

Alemdag, E., & Cagiltay, K. (2018). A systematic review of eye tracking research on multimedia learning. *Computers & Education*, *125*, 413–428. http://dx.doi.org/10.1016/j.compedu.2018.06.023

August, D., & Shanahan, T. (2006). *Developing literacy in second-language learners: Report of the National Literacy Panel on language-minority children and youth*. Mahwah, NJ: Erlbaum. http://dx.doi.org/10.2167/le129b.0

Beach, P., Martinussen, R., Poliszczuk, D., & Willows, D. (2018). A window into the classroom: Examining the use of virtual classrooms in teacher education. *Contemporary Issues in Technology and Teacher Education*, *18*(3), 578–600. https://www.citejournal.org/volume-18/issue-3-18/current-practice/a-window-into-the-classroom-examining-the-use-of-virtual-classrooms-in-teacher-education

Beach, P., & McConnel, J. (2019). Eye tracking methodology for studying teacher learning: A review of the research. *International Journal of Research & Method in Education*, *42*(5), 485–501. https://doi.org/10.1080/1743727X.2018.1496415

Carlisle, J., Kelcey, B., Rowan, B., & Phelps, G. (2011). Teachers' knowledge about early reading: Effects on students' gains in reading achievement. *Journal of Research on Educational Effectiveness*, *4*(4), 289–321. http://dx.doi.org/10.1080/19345747.2010.539297

Cash, A., Cabell, S., Hamre, B., DeCoster, J., & Pianta, R. (2015). Relating prekindergarten teacher beliefs and knowledge to children's language and literacy development. *Teaching and Teacher Education*, *48*, 97–105. http://dx.doi.org/10.1016/j.tate.2015.02.003

Castles, A., Rastle, K., & Nation, K. (2018). Ending the reading wars: Reading acquisition from novice to expert. *Psychological Science in the Public Interest*, *19*(1), 5–51. https://doi.org/10.1177%2F1529100618772271

Catrysse, L., Gijbels, D., & Donche, V. (2018). It is not only about the depth of processing: What if eye am not interested in the text? *Learning and Instruction*, *58*, 284–294. https://doi.org/10.1016/j.learninstruc.2018.07.009

Cheesman, E. A., McGuire, J. M., Shankweiler, D., & Coyne, M. (2009). First-year teacher knowledge of phonemic awareness and its instruction. *Teacher Education and Special Education*, *32*(3), 270–289. https://doi.org/10.1177%2F0888406409339685

Chiou, C. C., Tien, L. C., & Lee, L. T. (2015). Effects on learning of multimedia animation combined with multidimensional concept maps. *Computers & Education*, *80*, 211–223. https://doi.org/10.1016/j.compedu.2014.09.002

Cunningham, A. E., Zibulsky, J., Stanovich, K. E., & Stanovich, P. J. (2009). How teachers would spend their time teaching language arts: The mismatch between self-reported and best practices. *Journal of Learning Disabilities*, *42*(5), 418–430. https://doi.org/10.1177/0022219409339063

Desjarlais, M. (2017). The use of eye-gaze to understand multimedia learning. In C. Was, F. Sansosti, & B. Morris (Eds.), *Eye-tracking technology applications in educational research* (pp. 122–142). Hershey, PA: IGI Global.

Duguay, A., Kenyon, D., Haynes, E., August, D., & Yanosky, T. (2016). Measuring teachers' knowledge of vocabulary development and instruction. *Reading and Writing*, *29*(2), 321–347. http://dx.doi.org/10.1007/s11145-015-9598-4

Ely, E., Kennedy, M. J., Pullen, P. C., Williams, M. C., & Hirsch, S. E. (2014). Improving instruction of future teachers: A multimedia approach that supports implementation of evidence-based vocabulary practices. *Teaching and Teacher Education*, *44*, 35–43. http://dx.doi.org/10.1016/j.tate.2014.07.012

Gaudin, C., & Chaliès, S. (2015). Video viewing in teacher education and professional development: A literature review. *Educational Research Review*, *16*, 41–67. https://doi.org/10.1016/j.edurev.2015.06.001

Graham, S., McKeown, D., Kiuhara, S., & Harris, K. R. (2012). A meta-analysis of writing instruction for students in the elementary grades. *Journal of Educational Psychology*, *104*, 879–896. http://dx.doi.org/10.1037/a0029185

Hegarty, M., & Just, M. A. (1993). Constructing mental models of machines from text and diagrams. *Journal of Memory and Language*, *32*(6), 717–742. https://doi.org/10.1006/jmla.1993.1036

Hjetland, H. N., Brinchmann, E. I., Scherer, R., & Melby-Lervåg, M. (2017). Preschool predictors of later reading comprehension ability: A systematic review. *Campbell Systematic Reviews*, *14*, 1–156. http://hdl.handle.net/10852/59758

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing*, *2*(2), 127–160.

Hughes, J. E., Liu, S., & Lim, M. (2016). Technological modeling: Faculty use of technologies in preservice teacher education from 2004 to 2012. *Contemporary Issues in Technology and Teacher Education*, *16*(2), 184–207. https://www.learntechlib.org/primary/p/151896/

Jahanian, A., Keshvari, S., & Rosenholtz, R. (2018). Web pages: What can you see in a single fixation? *Cognitive Research: Principles and Implications*, *3*(1), 14. https://doi.org/10.1186/s41235-018-0099-2

Jarodzka, H., Scheiter, K., Gerjets, P., & Van Gog, T. (2010). In the eyes of the beholder: How experts and novices interpret dynamic stimuli. *Learning and Instruction*, *20*(2), 146–154. https://doi.org/10.1016/j.learninstruc.2009.02.019

Johnson, C. I., & Mayer, R. E. (2012). An eye movement analysis of the spatial contiguity effect in multimedia learning. *Journal of Experimental Psychology: Applied*, *18*(2), 178. http://dx.doi.org/10.1037/a0026923

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, *87*(4), 329–354. http://dx.doi.org/10.1037/0033-295X.87.4.329

Kennedy, M. J., Driver, M. K., Pullen, P. C., Ely, E., & Cole, M. T. (2013). Improving teacher candidates' knowledge of phonological awareness: A multimedia approach. *Computers & Education*, *64*, 42–51. http://dx.doi.org/10.1016/j.compedu.2013.01.010

Kennedy, M. J., & Thomas, C. N. (2012). Effects of content acquisition podcasts to develop preservice teachers' knowledge of positive behavioral interventions and supports. *Exceptionality*, *20*(1), 1–19. http://dx.doi.org/10.1080/09362835.2011.611088

Kirby, J. R., & Pedwell, D. (1991). Students' approaches to summarisation. *Educational Psychology*, *11*(3-4), 297–307.

Lai, M.-L., Tsai, M.-J., Yang, F.-Y., Hsu, C.-Y., Liu, T.-C., Lee, S…Tsai, C.-C. (2013). A review of using eye-tracking technology in exploring learning from 2000 to 2012. *Educational Research Review*, *10*, 90–115. https://doi.org/10.1016/j.edurev.2013.10.001

LeeSing, A. C., & Miles, C. A. (1999). The relative effectiveness of audio, video, and static visual computer-mediated presentations. *Canadian Journal of Education*, *24*(2), 212–221.

Lim, C. P. (2004). Engaging learners in online learning environments. *TechTrends*, *48*(4), 16–23.

Lindgaard, G., Fernandes, G., Dudek, C., & Brown, J. (2006). Attention web designers: You have 50 milliseconds to make a good first impression! *Behaviour & Information Technology*, *25*(2), 115–126. https://doi.org/10.1080/01449290500330448

Liu, H. C. (2018). Investigating the impact of cognitive style on multimedia learners' understanding and visual search patterns: An eye-tracking approach. *Journal of Educational Computing Research*, *55*, 1053–1068.

Liu, H. C., & Chuang, H. H. (2011). An examination of cognitive processing of multimedia information based on viewers' eye movements. *Interactive Learning Environments*, *19*(5), 503–517. http://dx.doi.org/10.1080/10494820903520123

Martinussen, R., Ferrari, J., Aitken, M., & Willows, D. (2015). Pre-service teachers' knowledge of phonemic awareness: Relationship to perceived knowledge, self-efficacy beliefs, and exposure to a multimedia-enhanced lecture. *Annals of Dyslexia*, *65*(3), 142–158. http://dx.doi.org/10.1007/s11881-015-0104-0

Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions? *Educational Psychologist*, *32*(1), 1–19. https://doi.org/10.1207/s15326985ep3201_1

Mayer, R. E. (2014). Incorporating motivation into multimedia learning. *Learning and Instruction*, *29*, 171–173. https://doi.org/10.1016/j.learninstruc.2013.04.003

McCutchen, D., Abbott, R., Green, L., Beretvas, N., Cox, S., Potter, N. … Gray, A. (2002). Beginning literacy: Links among teacher knowledge, teacher practice, and student learning. *Journal of Learning Disabilities*, *35*(1), 69–86. https://doi.org/10.1177/002221940203500106

Moats, L. C., & Foorman, B. R. (2003). Measuring teachers' content knowledge of language and reading. *Annals of Dyslexia*, *53*(1), 23–45. https://doi.org/10.1007/s11881-003-0003-7

Moreno, R., & Mayer, R. (2007). Interactive multimodal learning environments. *Educational Psychology Review*, *19*(3), 309–326. https://doi.org/10.1007/s10648-007-9047-2

National Research Council. (2000). *How people learn: Brain, mind, experience, and school: Expanded edition*. Washington, DC: National Academies Press.

Ontario Institute for Studies in Education (OISE). (2012). The balanced literacy diet: Putting research into practice in the classroom. Retrieved from https://www.oise.utoronto.ca/balancedliteracydiet/Home/index.html

Ottley, J., Piasta, S., Mauck, S., O'Connell, A., Weber-Mayrer, M., & Justice, L. (2015). The nature and extent of change in early childhood educators' language and literacy knowledge and beliefs. *Teaching and Teacher Education*, *52*, 47–55. https://doi.org/10.1016/j.tate.2015.08.005

Paivio, A. (1986). *Mental representations: A dual coding approach*. Oxford, England: Oxford University Press.

Piasta, S., Justice, L., McGinty, A., & Kaderavek, J. (2012). Increasing young children's contact with print during shared reading: Longitudinal effects on literacy achievement. *Child Development*, *83*(3), 810–820. https://doi.org/10.1111/j.1467-8624.2012.01754.x

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, *124*(3), 372–422. https://doi.org/10.1037/0033-2909.124.3.372

Rayner, K., Rotello, C. M., Stewart, A. J., Keir, J., & Duffy, S. A. (2001). Integrating text and pictorial information: Eye movements when looking at print advertisements. *Journal of Experimental Psychology: Applied*, *7*, 219–226. https://doi.org/10.1037/1076-898X.7.3.219

Scheiter, K., & Eitel, A. (2017). The use of eye tracking as a research and instructional tool in multimedia learning. In C. Was, F. Sansosti, & B. Morris (Eds.), *Eye-tracking technology applications in educational research* (pp. 143–165). Hershey, PA: IGI Global.

Schmidt-Weigand, F., Kohnert, A., & Glowalla, U. (2010). A closer look at split visual attention in system-and self-paced instruction in multimedia learning. *Learning and Instruction*, *20*(2), 100–110. https://doi.org/10.1016/j.learninstruc.2009.02.011

Schnotz, W. (2014). Integrated model of text and picture comprehension. In R. E. Mayer (Ed.), *Cambridge handbook of multimedia learning* (2nd ed., pp. 72–103). Cambridge, England: Cambridge University Press.

Schnotz, W., Baadte, C., Johnson, A., & Mengelkamp, C. (2012). Knowledge acquisition from verbal and pictorial information. In J. R. Kirby & M. J. Lawson (Eds.), *Enhancing the quality of learning: Dispositions, instruction, and learning processes* (pp. 339–365). Cambridge, England: Cambridge University Press.

Sherin, M. G., & Russ, R. S. (2014). Teacher noticing via video. In B. Calandra & P. J. Rich (Eds.), *Digital video for teacher education* (pp. 3–20). New York, NY: Routledge.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, *12*(2), 257–285. https://doi.org/10.1016/0364-0213(88)90023-7

Visser, R., Evering, L., & Barrett, D. (2014). #TwitterforTeachers: The implications of Twitter as a self-directed professional development tool for K–12 teachers. *Journal of Research on Technology in Education*, *46*(4), 396–413. https://doi.org/10.1080/15391523.2014.925694

Wren, S. (2000). *The cognitive foundations of learning to read: A framework*. Austin, TX: Southwest Educational Development Library. Retrieved from https://www.sedl.org/reading/framework/framework.pdf

Zottmann, J. M., Stegmann, K., Strijbos, J. W., Vogel, F., Wecker, C., & Fischer, F. (2013). Computer-supported collaborative learning with digital video cases in teacher education: The impact of teaching experience on knowledge convergence. *Computers in Human Behavior*, *29*(5), 2100–2108. https://doi.org/10.1016/j.chb.2013.04.014

Appendix A

Summary of Group Differences (N = 18)

	Experienced Teachers		Pre-Service Teachers				
	M	*SD*	*M*	*SD*	*t*-value	*p*	*d*
Total Recording (secs)	127.29	57.49	94.09	31.39	1.59	.131	0.72
Total Fixation Duration of Keyword AOIs (secs)	14.95	8.80	10.17	7.27	1.26	.227	0.59
Total Fixation Duration of Pyramid AOIs (secs)	64.29	35.10	33.77	22.70	2.26	.039*	1.03
Total Fixation Count of Keyword AOIs	75.86	34.00	56.09	32.22	1.24	.232	0.60
Total Fixation Count of Pyramid AOIs	254.29	138.10	144.72	75.80	2.19	.044*	0.98
Transfer Score	6.86	3.13	4.55	1.97	1.94	.071	0.88
Retention Score	9.71	3.82	6.09	2.47	2.46	.026*	1.13
Test of Literacy Knowledge Score	7.86	2.12	3.45	1.37	5.40	<.001*	2.47

* $p < .05$

Appendix B

Summary of Group Differences in Areas of Interest (AOI)—Fixation Count

	Experienced Teachers		Pre-Service Teachers				
AOI	*M*	*SD*	*M*	*SD*	*t*-value	*p*	*d*
Comprehension Block	20.29	13.94	16.09	8.57	0.796	.438	0.36
Oral Language Block	28.29	14.15	18.00	11.74	1.675	.113	0.79
Comprehension Strategies Block	35.71	24.16	24.36	13.42	1.289	.216	0.58
Knowledge Building Block	17.71	10.67	13.36	7.35	1.029	.319	0.47
Phonemic Awareness Block	16.86	8.13	12.64	8.52	1.042	.313	0.51
Vocabulary Block	22.14	13.26	11.81	6.85	2.188	.044*	0.98
Fluency Block	39.57	26.42	16.27	11.77	2.198	.061	1.14
Text Structures Block	28.29	12.49	12.36	8.35	3.26	.005*	1.49
Phonics Block	27.71	16.52	11.18	7.97	2.87	.011*	1.27
Concepts of Print Block	17.71	11.29	8.63	4.13	2.041	.080	1.07

* $p < .05$

Summary of Group Differences in Areas of Interest (AOI)—Fixation Duration (seconds)

	Experienced Teachers		Pre-Service Teachers				
AOI	*M*	*SD*	*M*	*SD*	*t*-value	*p*	*d*
Comprehension Block	4.93	3.74	3.42	2.48	1.03	.317	0.48
Oral Language Block	6.52	3.76	4.15	2.93	1.5	.154	0.70

	Experienced Teachers		Pre-Service Teachers				
AOI	*M*	*SD*	*M*	*SD*	*t*-value	*p*	*d*
Comprehension Strategies Block	7.82	5.17	5.02	3.92	1.31	.210	0.61
Knowledge Building Block	4.55	3.05	3.28	2.34	1.00	.331	0.47
Phonemic Awareness Block	4.20	1.94	3.24	3.19	0.71	.490	0.36
Vocabulary Block	4.77	2.56	2.52	1.46	2.39	.030*	1.08
Fluency Block	9.88	7.09	3.92	2.75	2.12	.071	1.11
Text Structures Block	8.20	4.1	3.04	2.7	3.24	.005*	1.49
Phonics Block	8.49	4.71	3.21	2.54	3.11	.007*	1.39
Concepts of Print Block	4.92	3.07	1.95	1.28	2.42	.044*	1.26

* $p < .05$

Appendix C

Average Correct Responses on Pre-Test of Literacy Knowledge

	Experienced Teachers		Pre-Service Teachers				
	M	*SD*	*M*	*SD*	*t*-value	*p*	*d*
Phonemic awareness (PA) Instruction 1	0.57	0.54	0.09	0.30	2.17	.060	1.10
PA Instruction 2	0.14	0.38	0.09	0.30	0.32	.751	0.15
PA Instruction 3	0.86	0.38	0.18	0.41	3.54	.003*	1.72
Spelling and PA	0.71	0.49	0.20	0.42	2.32	.035*	1.12
Vocabulary Instruction	1.00	0.00	0.36	0.51	4.18	.002*	2.02
Receptive and Expressive Vocabulary	0.86	0.38	1.00	0.00	1.00	.356	0.52
Vocabulary and Prior Knowledge	0.00	0.00	0.09	0.30	0.79	.442	0.42
Vocabulary Knowledge	0.14	0.38	0.00	0.00	1.00	.356	0.52
Fluency (Maximum Score = 6)	2.29	1.25	0.64	0.51	-3.94	.012	1.73
Reading Comprehension (Maximum Score = 3)	1.29	0.95	1.00	0.45	.043	.399	0.39
Overall Correct responses	7.86	2.12	3.45	1.37	5.40	<.001*	2.47

* $p < .05$

Appendix D

Pearson Correlations Between Pre-Test Scores and Fixation Counts on AOIs of Pyramid

	1	2	3	4	5	6	7	8
1. PA Instruction 1	-							
2. PA Instruction 2	.18	-						
3. PA Instruction 3	.44	.04	-					
4. Spelling & PA	.51*	.07	.65**	-				
5. Vocabulary Instruction	.50*	-.08	.48*	.46	-			
6. Receptive and Expressive Vocab	.17	.10	.26	.25	-.17	-		
7. Fluency/Auto Score	.28	.07	.36	.40	.49*	-.14	-	
8. RC Score	-.11	-.06	.19	.21	.14	.42	.18	-
9. Comprehension AOI	.14	.04	.19	-.20	-.02	.28	.03	.43
10. Oral Language AOI	.12	.16	.43	.22	.06	.28	.14	.46
11. Comprehension Strategies AOI	.00	.04	.36	.13	.05	.30	.14	.66**
12. Knowledge Building AOI	-.08	-.02	.32	.08	.06	.25	.15	.49*
13. Phonemic Awareness AOI	-.02	.18	.37	.20	-.06	.33	.21	.41
14. Vocabulary AOI	.06	.01	.46	.25	.28	.22	.26	.66**
15. Fluency AOI	.25	-.06	.50*	.32	.20	.18	.20	.53*
16. Text Structures AOI	.38	.17	.61**	.33	.25	.25	.36	.40
17. Phonics AOI	.30	.06	.51*	.26	.23	.24	.39	.48*
18. Concepts of Print AOI	.21	-.03	.62**	.17	.29	.27	.28	.51*

p < .05; ***p* < .01

Pearson Correlations Between Pre-Test Scores and Fixation Durations on AOIs of Pyramid

	1	2	3	4	5	6	7	8
1. PA Instruction 1	-							
2. PA Instruction 2	.18	-						
3. PA Instruction 3	.44	.40	-					
4. Spelling & PA	.51*	.07	.65**	-				
5. Vocabulary Instruction	.50*	-.08	.48*	.46	-			
6. Receptive and Expressive Vocab	.17	.10	.26	.25	-.17	-		
7. Fluency/Auto Score	.28	.07	.37	.40	.49*	-.14	-	
8. RC Score	-.11	-.06	.19	.21	.14	.42	.18	-

	1	2	3	4	5	6	7	8
9. Comprehension AOI	.20	.06	.18	-.16	.01	.21	.08	.37
10. Oral Language AOI	.29	.16	.32	-.01	.13	.29	.19	.33
11. Comprehension Strategies AOI	.03	.13	.26	.05	.06	.20	.21	.53*
12. Knowledge Buildin g AOI	.12	.05	.22	-.09	.12	.24	.21	.30
13. Phonemic Awareness AOI	.02	-.02	.16	.03	-.07	.24	.15	.37
14. Vocabulary AOI	.15	-.08	.43	.23	.33	.22	.38	.62**
15. Fluency AOI	.23	-.08	.44	.28	.23	.16	.18	.59**
16. Text Structures AOI	.48*	.14	.51*	.21	.29	.20	.37	.29
17. Phonics AOI	.38	.15	.51*	.31	.26	.25	.36	.52*
18. Concepts of Print AOI	.41	.14	.56*	.17	.35	.26	.31	.40

* $p < .05$; **$p < .01$

Appendix E

Pearson Correlations Between Post-Task Scores and Fixation Durations on AOIs of Pyramid and Keywords in the Text

	1	2
1. Transfer Score	-	
2. Retention Score	.35	-
3. Comprehension AOI	.33	.13
4. Oral Language AOI	.37	.25
5. Comprehension Strategies AOI	.15	.34
6. Knowledge Building AOI	.26	.26
7. Phonemic Awareness AOI	-.02	.33
8. Vocabulary AOI	.15	.55*
9. Fluency AOI	.12	.43
10. Text Structures AOI	.38	.36
11. Phonics AOI	.39	.52*
12. Concepts of Print AOI	.45	.37
13. "Building Blocks"	-.10	.15
14. "Language Components"	.10	.14
15. "Language Skills"	.16	.21
16. "Make Meaning"	-.24	.29
17. "Print Components"	.05	-.02
18. "Print Skills"	.35	.12
19. "Pyramid"	.46	.38
20. "Recognize Words"	-.22	.07

* $p < .05$; ** $p < .01$