

8-23-2016

Individual Differences in Evaluating the Credibility of Online Information in Science: Contributions of Prior Knowledge, Gender, Socioeconomic Status, and Offline Reading Ability

Elena Forzani
elenaforzani@gmail.com

Follow this and additional works at: <https://opencommons.uconn.edu/dissertations>

Recommended Citation

Forzani, Elena, "Individual Differences in Evaluating the Credibility of Online Information in Science: Contributions of Prior Knowledge, Gender, Socioeconomic Status, and Offline Reading Ability" (2016). *Doctoral Dissertations*. 1242.
<https://opencommons.uconn.edu/dissertations/1242>

Individual Differences in Evaluating the Credibility of Online Information in Science:
Contributions of Prior Knowledge, Gender, Socioeconomic Status, and Offline Reading Ability

Elena Forzani, Ph.D.

University of Connecticut

2016

Abstract

This study investigated how seventh grade students performed on a measure of online critical evaluation in science (the ORCA). The analysis included evaluating the extent to which critical evaluation also appeared to be an aspect of other elements of online research and comprehension, including reading to locate information, reading to synthesize information, and reading and writing to communicate information. Additionally, this study examined the extent to which several important individual difference variables affected students' ability to critically evaluate information during online reading in science. The individual difference variables evaluated in this study included prior knowledge, gender, socioeconomic status, and offline reading ability. Participants ($n = 1,434$) included seventh grade students from two states in the Northeast United States.

This study used a multiple theoretical perspectives approach (Labbo & Reinking, 1999) to frame the study. Three theoretical perspectives were employed that included theories of offline (RAND Reading Study Group, 2002; Anderson & Pearson, 1984) and online reading (Leu, Kinzer, Coiro, Cammack, & Henry, 2013), perspectives on individual differences (Afflerbach, 2015), and a disciplinary literacy framework (Shanahan & Shanahan, 2008) for science. These perspectives are integrated in a way that forms the basis for a framework of

critical evaluation of online information in science, a framework that takes into account the role of individual differences in the reading comprehension process.

Multiple regression analysis was used to evaluate the shared variance among critical evaluation and the three other skill areas. Multilevel modeling (MLM) was used to compare mean differences in scores between critical evaluation and the other three skill areas. MLM also was used to evaluate the effects of the four individual difference variables on students' online critical evaluation abilities. Both student-level and school-level effects were evaluated. Findings suggest that critical evaluation is a somewhat unique and difficult dimension of online research and comprehension. Findings also suggest that student-level prior knowledge, gender, and offline reading, as well as school-means for offline reading, have a significant effect on students' ability to evaluate online information in science. Results are discussed in the context of theory development, research, assessment, and instruction.

Individual Differences in Evaluating the Credibility of Online Information in Science:
Contributions of Prior Knowledge, Gender, Socioeconomic Status, and Offline Reading Ability

Elena Forzani

B.A., Occidental College, 2004

M.A., University of Michigan, 2009

A Dissertation

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

at the

University of Connecticut

2016

Copyright by

Elena Forzani

2016

APPROVAL PAGE

Doctor of Philosophy Dissertation

Individual Differences in Evaluating the Credibility of Online Information in Science:
Contributions of Prior Knowledge, Gender, Socioeconomic Status, and Offline Reading Ability

Presented by

Elena Forzani, B.A., M.A.

Major Advisor _____
Donald J. Leu

Associate Advisor _____
Mary Anne Doyle

Associate Advisor _____
Michael A. Coyne

Associate Advisor _____
Christopher Rhoads

University of Connecticut
2016

ACKNOWLEDGEMENTS

A dissertation is a large undertaking, and this dissertation would not have been possible without the assistance and support of many people. While it is not possible to mention everyone who contributed in large and small ways, there are a few key people I would like to acknowledge here. First, thanks is extended to my advisory committee, each of whom contributed valuable feedback and guidance throughout the proposal and dissertation process. Mary Anne Doyle continually pushed me to focus on the implications of the present study for students, teachers, and instruction. Michael Coyne provided valuable questions that helped me focus on instruction, individual differences, and the ways in which these factors impact students. Chris Rhoads provided invaluable guidance and insight around how best to conduct the analyses in this study and interpret the results. He did so in a patient, careful, and educative way that helped me consider analysis in ways valuable beyond the scope of this present project.

P. David Pearson and Peter Afflerbach both contributed important thoughts during the proposal phase of this study related to the study methods, reading research and practice, and individual differences. Similarly, Gina Cervetti and Jason Braasch contributed important questions and insights to the dissertation, focusing on scientific literacy and critical evaluation, respectively. Together, these contributions provided multiple, expert perspectives that ultimately strengthened the study.

Additionally, thanks goes to Julie Coiro, a co-principal investigator on the ORCA Project whose many conversations with me over the past few years about online reading and critical evaluation helped shape and deepen my thinking about how students evaluate information when reading online. These thoughts contributed to the perspectives contained in the present study.

Thanks also goes to Cheryl Maykel, with whom I collected data, scored student responses, conducted analyses, and wrote throughout my time with the ORCA Project. Having a respected colleague and friend to work with day in and day out made working on this project a true pleasure both professionally and personally. Thanks also to Donna Bone, for her special management and assistance with project tasks, school relationships and communications, and for her friendship and support while I worked on this project.

Finally, special thanks is extended to my advisor, Don Leu, whose support and guidance over the past five years, leading to the present study, has been immeasurable. As lead investigator on The ORCA Project, the data used for this study was collected thanks to his vision and management. As advisor, Don has provided countless opportunities, insights, and support that have helped me grow both personally and professionally, and these are reflected in the present study. Don's relentless focus both on both helping students learn and on pushing the online reading field forward have provided direction for me for this study and beyond.

TABLE OF CONTENTS

| | |
|---|------|
| ACKNOWLEDGEMENTS | iv |
| LIST OF FIGURES | ix |
| LIST OF TABLES | xi |
| LIST OF APPENDICES | xiii |
| CHAPTER I | 1 |
| INTRODUCTION AND OVERVIEW OF THE STUDY | 1 |
| Introduction | 1 |
| Statement of the Problem | 2 |
| Background of the Study | 4 |
| Methods and Procedures | 14 |
| Significance of the Study | 17 |
| CHAPTER II | 23 |
| REVIEW OF THE LITERATURE | 23 |
| Introduction | 23 |
| Theoretical Perspectives | 27 |
| Perspectives on Reading | 28 |
| Perspectives On Individual Differences | 32 |
| Disciplinary Literacy and Scientific Literacy | 33 |
| Integrating the Perspectives | 37 |
| Prior Research | 40 |
| Online Research and Comprehension | 40 |
| Critical Evaluation | 53 |
| Scientific Literacy | 62 |
| Science texts | 63 |
| Individual Difference Variables in Reading and Science | 71 |
| Integrating Perspectives and Research: A Framework for Discipline-specific Online Research and Comprehension in Science | 82 |
| Online Science Text | 85 |
| Online Science Readers: Strategies and Individual Difference Variables | 86 |
| Online Science Activities and Context | 89 |
| Chapter Summary | 93 |
| CHAPTER III | 94 |
| METHODS AND PROCEDURES | 94 |
| Participants | 94 |
| Instrumentation | 95 |
| Online Research and Comprehension Assessments-II (ORCA-IIs) | 95 |
| Two formats and four skill areas in the ORCA-IIs | 98 |
| Prior Knowledge Measures | 115 |
| Offline Reading Measures (ORMs) | 116 |
| Data Collection Procedures | 118 |

| | |
|--|-----|
| Online Research and Comprehension Assessments (ORCAs) | 118 |
| Prior Knowledge Measures | 118 |
| Demographic Data: Gender and Socioeconomic Status | 119 |
| Offline Reading Measures (ORMs) | 120 |
| Scoring | 120 |
| Online Research and Comprehension Assessments-II (ORCA-IIs) | 120 |
| Prior Knowledge Measures | 121 |
| Offline Reading Measures (ORMs) | 121 |
| Analysis | 122 |
| Research question 1: Exploring the Nature of Students' Ability to Critically Evaluate in Relation to Students' Ability to Locate, Synthesize, and Communicate During Online Reading in Science | 122 |
| Research question 2: Investigating the Effects of Prior Knowledge, Gender, SES, and Offline Reading Ability on Students' Ability to Critically Evaluate Online Information.. | 123 |
| Evaluating Missing Data | 125 |
| Limitations | 125 |
| CHAPTER IV | 127 |
| RESULTS | 127 |
| Research Question 1: Comparing Critical Evaluation to Location, Synthesis, and Communication | 127 |
| The First Set of Analyses for Research Question 1 | 127 |
| The Second Set of Analyses for Research Question 1 | 133 |
| Summary of the second set of analyses for Research Question 1 | 135 |
| Summary of Results for Research Question 1 | 135 |
| Research Question 2: Investigating the Effects of Prior Knowledge, Gender, SES, and Offline Reading Ability on Students' Ability to Critically Evaluate | 137 |
| The Unconditional Model | 137 |
| The Conditional Model | 138 |
| Summary of the Results for Research Question 2 | 140 |
| Evaluating the Loss of Data | 142 |
| The First Set of Analyses | 142 |
| The Second Set of Analyses | 144 |
| Chapter Summary | 146 |
| CHAPTER V | 150 |
| DISCUSSION | 150 |
| Research question 1: Exploring the Nature of Students' Ability to Critically Evaluate in Relation to Students' Ability to Locate, Synthesize, and Communicate During Online Reading in Science | 150 |
| Critical Evaluation is a Unique and Difficult Skill Area for Students in Online Reading . | 150 |
| Exploring the Reasons for the Difficulty of Critical Evaluation in the ORCAs | 152 |
| Research question 2: Investigating the Effects of Prior Knowledge, Gender, SES, and Offline Reading Ability on Students' Ability to Critically Evaluate | 162 |
| Prior Knowledge | 162 |
| Gender | 167 |
| Offline Reading | 169 |

| | |
|--|-----|
| Socioeconomic Status | 172 |
| Evaluating Data Loss | 174 |
| Implications..... | 174 |
| Importance of Focusing on Discipline-Specific Online Critical Evaluation Skills When Teaching and Assessing Online Reading..... | 175 |
| Possibility for Unique Influences of Individual Difference Variables in an Online Environment..... | 176 |
| Developing a Model for Disciplinary Online Research and Comprehension..... | 183 |
| Addressing the Challenges and Promises of Individual Differences in Critical Evaluation During Online Reading in Science | 185 |
| REFERENCES | 188 |
| APPENDICES | 226 |

LIST OF FIGURES

| | |
|---|------------|
| <i>Figure 2.1. A Framework for the Process of Critically Evaluating and Constructing Meaning During a Discipline-specific Online Research and Comprehension Task.....</i> | <i>39</i> |
| <i>Figure 2.2. A Student Collaborating With An Avatar in the ORCA Social Networking Environment.....</i> | <i>48</i> |
| <i>Figure 2.3. The Avatar Selection Screen At the Beginning of the ORCA.....</i> | <i>50</i> |
| <i>Figure 2.4. The Email Message Defining the Research Task in the ORCAs.....</i> | <i>53</i> |
| <i>Figure 2.5. “How Do Energy Drinks Affect Heart Pressure?”: A Science Webpage in the Energy Drinks and Heart Health Task.....</i> | <i>67</i> |
| <i>Figure 2.6. The Three Steps and Five Core Strategies of Online Research and Comprehension Within a Given Discipline: A Working Model for Disciplinary Online Research and Comprehension.....</i> | <i>84</i> |
| <i>Figure 2.7. The Energy Drinks and Heart Health Webpage Used to Assess Critical Evaluation Skills.....</i> | <i>85</i> |
| <i>Figure 2.8. The Video Games and Eye Health Webpage Used to Assess Critical Evaluation Skills.....</i> | <i>88</i> |
| <i>Figure 3.1. The Gloogle Search Tool Used to Locate Information in the ORCAs.....</i> | <i>99</i> |
| <i>Figure 3.2. The Notepad Tool in the ORCA Used to Aid Students in Synthesizing Information Throughout the Task.....</i> | <i>102</i> |
| <i>Figure 3.3. The Third Synthesis Score Point in the ORCA.....</i> | <i>103</i> |
| <i>Figure 3.4. The Email Communication Tool in the ORCA.....</i> | <i>106</i> |
| <i>Figure 3.5. The Wiki Communication Tool in the ORCA: Mr. Henry’s Classroom Wiki.....</i> | <i>107</i> |
| <i>Figure 3.6. Critical Evaluation Sequence Within the ORCA-II Virtual.....</i> | <i>109</i> |
| <i>Figure 3.7. The Snacks and Heart Health Webpage Used for the Evaluation Scale.....</i> | <i>113</i> |
| <i>Figure 3.8. The Demographic Data Collection Screen in the ORCA-IIs.....</i> | <i>116</i> |

| | |
|---|-----|
| <i>Figure 3.9.</i> The Login Screen for the ORCA-IIs..... | 119 |
| <i>Figure 3.10.</i> A Portion of A Score Report in the ORCA Scoring System..... | 121 |
| <i>Figure 5.1.</i> The “About the Author” Page for the Video Games and Eye Health Task..... | 154 |

LIST OF TABLES

| | |
|---|-----|
| Table 3.1. <i>Demographic Data for State A and State B</i> | 95 |
| Table 3.2. <i>ORCA-II Items by Skill Area</i> | 97 |
| Table 3.3. <i>Scoring Criteria for the Locate Scale for the Video Games and Eyesight Task</i> | 101 |
| Table 3.4. <i>Scoring Criteria for the Synthesize Scale for the Video Games and Eye Health Task</i> | 104 |
| Table 3.5. <i>Scoring Criteria for the Communicate Scale for the Video Games and Eye Health Task</i> | 108 |
| Table 3.6. <i>Scoring Criteria for the Critical Evaluation Scale for the Video Games and Eye Health Task</i> | 111 |
| Table 3.7. <i>Methodology and Data Analysis Methods for the Two Research Questions</i> | 124 |
| Table 4.1. <i>Means and Standard Deviations for the Four Skill Areas, the Four Individual Evaluate Score Points, and the Individual Difference Variables</i> | 128 |
| Table 4.2. <i>Percentage of Students Scoring Correctly On the Critical Evaluation Items</i> | 129 |
| Table 4.3. <i>Bivariate Pearson Correlations Among Dependent and Independent Variables</i> | 130 |
| Table 4.4. <i>Regression Analyses of the Individual Locate, Synthesize, and Communicate Skill Areas on the Evaluate Skill Area</i> | 131 |
| Table 4.5. <i>Multiple Regression Analysis of the Locate, Synthesize, and Communicate Skill Area on the Evaluate Skill Area</i> | 132 |
| Table 4.6. <i>Parameter Estimates for Fixed and Random Effects for Unconditional Models of the Difference Between Each Skill Area and the Evaluate Skill Area</i> | 134 |
| Table 4.7. <i>Fixed Effects Estimates (Top) and Covariance Parameters (Bottom) for Models of the</i> | |

| | |
|--|------------|
| <i>Predictors of the Evaluation Skill Area.....</i> | <i>139</i> |
| Table 4.8. <i>Comparing Students With No ORCA-Virtual Data to Those with Complete ORCA-</i> | |
| <i>Virtual Data.....</i> | <i>142</i> |
| Table 4.9. <i>Comparing Students with Partial ORCA-Virtual Data to Those with Complete ORCA-</i> | |
| <i>Virtual Data.....</i> | <i>143</i> |

LIST OF APPENDICES

| | |
|--|-----|
| Appendix A. The Prior Knowledge Measures in the ORCA-II: Heart and Eyes..... | 218 |
| Appendix B. The Critical Evaluation Webpages for the Four Science Tasks in the ORCAs.... | 224 |
| Appendix C. The “About the Author” Pages for the Four Science Tasks in the ORCAs..... | 230 |
| Appendix D. Offline Reading Measure (ORM) Used in the Present Study..... | 234 |

CHAPTER I

INTRODUCTION AND OVERVIEW OF THE STUDY

Introduction

Literacy skills in science are especially important today for full participation in society and for the nation's progress (National Science and Technology Council, 2013; National Research Council, 2012; OECD, 2013). One of the most important of these literacy skills is the ability to critically evaluate the credibility of online information (Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012). In the digital information age in which we now live, the ability to critically evaluate the credibility of information during online reading in science will help define our students' and our nation's futures.

The purpose of the present study was twofold. First, this study aimed to explore the nature of seventh grade students' ability to critically evaluate online information in science. This included exploring the extent to which critical evaluation is a unique aspect of online reading compared to location, synthesis, and communication. This also included investigating students' performance in critical evaluation compared to these three other skill areas. Second, this study aimed to investigate the effects of four individual difference variables that included prior knowledge, gender, socioeconomic status (SES), and offline reading ability, on students' ability to critically evaluate online information in science. This quantitative study both expands and focuses prior research findings in online reading and individual differences.

This study expands prior research findings in online reading by investigating the abilities of a relatively large and diverse sample of students across two different states and within the context of a performance-based assessment. This study expands research in individual differences by exploring individual differences not just in offline reading (see, for example,

Afflerbach, 2015) but in online reading as well. This study focuses prior research findings in both online reading and individual differences by examining the impacts of four particular individual difference variables on the specific online reading skill of critical evaluation and within the context of the discipline of science. Results of this study may help to provide direction for theory, research, assessment, and instruction to support efforts to address the needs of diverse readers in online science contexts.

Statement of the Problem

Today, literacy abilities circumscribe the extent of many of our opportunities and define our capacity to engage in society both personally and professionally. In today's information age, the ability to comprehend and use informational texts, especially, has become a necessary and critical component for college, work, and life in an informational society (National Governors Association Center for Best Practices, 2010). Arguably, those who are able to use information most effectively have the greatest opportunities in our society (Castells, 2000; Webster, 2006). One of the key contexts of the information that we use today is the Internet (Leu et al., 2011). Yet, the Internet has significantly altered the nature of literacy, requiring students to learn new literacy skills if they wish to engage fully in society (Leu, Kinzer, Coiro, Castek, & Henry, 2013).

In a society that is built upon the notion of equality, providing all students with the opportunity to learn informational literacy skills, particularly those required by the Internet, is essential (Leu et al., 2015). Informational literacy skills in science are especially important now for full engagement in society and for the nation's progress (National Science and Technology Council, 2013; National Research Council, 2012; OECD, 2013). One of the most important of these informational literacy abilities that lies at the intersection of science and the Internet is the

ability to critically evaluate online information in science. Given that much of the information with which we interact today, including scientific information, is found online (Leu et al., 2013; Thomm & Bromme, 2016), the ability to read and learn from valid and reliable online information has become a central aspect of students' life opportunities (Organisation for Economic Cooperation and Development, 2010). This is especially true in science, as the ability to critically evaluate scientific information is one of the key skillsets students need for science (Halverson, Siegel & Freyermuth, 2010; NGSS Lead States, 2013).

Despite the importance of critical evaluation of online information in science, few studies have investigated students' abilities in this area, and this area is not well understood. One aspect of this area that is especially important and has been studied extensively in offline reading and offline science but has been little studied in online reading and online science is the role of individual differences in reading and science ability, which greatly affect students' learning (Afflerbach, 2015; OECD, 2015). If we hope to help all students develop their literacy skills for science and provide all students with equal opportunity to do so, we need to better understand online critical evaluation, especially in science, and the role that individual differences play in students' abilities in these areas.

In response, the present study seeks to initiate a better understanding of middle school students' online critical evaluation capabilities within the area of science and with an eye towards individual differences. The purpose of the proposed study therefore is to investigate both the uniqueness and difficulty of critical evaluation of online information in science, especially compared to three other online reading skills, and to investigate the effects of four individual difference variables on that performance. Specifically, this study will investigate the following two research questions:

- 1) What is the nature of students' ability to critically evaluate online information in relation to three other skill areas required during online reading in science?
- 2) During online reading in science, to what extent do prior knowledge, gender, SES, and offline reading ability contribute to students' ability to critically evaluate the credibility of online information?

The first research question aims to explore both the uniqueness and difficulty of online critical evaluation in science. First, this question aims to explore the uniqueness of critical evaluation by examining the extent to which critical evaluation also involves aspects of location, synthesis, and communication during online reading in science. Second, this question aims to explore the difficulty of online critical evaluation in science by investigating students' abilities in this skill area compared to the other three skill areas required during online reading in science. The second research question aims to explore students' performance on critical evaluation in more depth by investigating the contributions of prior knowledge, gender, SES, and offline reading ability during online reading in science.

The findings from this study will provide educators and researchers with a better understanding of middle school students' abilities in critically evaluating online information, a highly important area but one for which we have little information. Moreover, the findings will provide important initial information that can be used in both research and practice about how individual differences are associated with critical evaluation of online information in science.

Background of the Study

Today, much of the information with which we interact, including scientific information, is found online (Leu et al., 2013). As a result, the ability to read and learn from valid and reliable online information has become a central aspect of students' life opportunities (Organisation for

Economic Cooperation and Development, 2010). Given that anyone may publish what they wish online and there are few uniform standards in this informational environment, the ability to critically evaluate the credibility of online information has become a particularly important skill for readers today (Goldman et al., 2012; Wiley et al., 2009).

Today's readers must read and comprehend large amounts of online information, often within the process of an online inquiry task, if they are to be successful both in work and in life (Common Core State Standards Initiative, 2010; Organisation for Economic Co-operation and Development & the Centre for Educational Research and Innovation, 2010). Reading online information, where anyone may publish anything, necessarily relies upon effective critical evaluation skills (Graesser et al., 2007). Yet, this skill area is often the area of online reading with which students struggle the most (Forzani & Burlingame, 2012; Kuiper & Volman, 2008).

Critical evaluation is particularly relevant for the field of science, since the ability to critically evaluate information is one of the key skill sets students need for doing science (Halverson, Siegel & Freyermuth, 2010; NGSS Lead States, 2013). Despite the importance of critical evaluation in online reading and, especially, in the area of science, few studies have measured students' ability in this skillset. Additionally, few studies have done so by using a simulated Internet environment, a potentially more authentic and accurate assessment format compared to that of multiple-choice (see de Klerk, Veldkamp, & Eggen, 2015). Examining critical evaluation during online reading in particular disciplinary areas is important if we hope to gain a fuller understanding of how critical evaluation functions during online reading and what unique differences there may be in different disciplinary areas.

Currently, science is a particularly critical disciplinary area for students' learning (National Science and Technology Council, 2013). Scientific literacy, or the reading and writing

skills fundamental to the work of science (Cervetti, Pearson, Bravo, and Barber, 2005), has become an exceedingly important yet lacking skill for students in the United States (National Science and Technology Council, 2013). This is especially true for evaluating science texts in online environments (Bray Speth et al., 2010; Porter et al., 2010), as critical evaluation is an important component of scientific understanding (Halverson, Siegel & Freyermuth, 2010; NGSS Lead States, 2013). This is problematic given the importance of science for full participation in society today (National Science and Technology Council, 2013).

Not surprisingly then, evaluating scientific evidence is emphasized in the National Science Education Standards (NGSS Lead States, 2013). For example, in Grades 6-8, one of the core scientific practices is: “Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used and describe how they are supported or not supported by evidence” (p. 65). Specifically, throughout the grade levels, students are expected to be able to “construct a scientific explanation based on valid and reliable evidence obtained from sources” (p. 75). In order to do so, students must “evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments (p. 101). Finally, the standards state that students should be able to “Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying data when possible” (p. 101). Without the skill to critically evaluate their sources, students often develop misconceptions about scientific information from unreliable sources (Wiley et al., 2009). Developing misconceptions, or inaccurate ideas, can hinder comprehension by making it difficult to understand new information when reading (Alvermann, Smith & Readence, 1985; Diakidoy & Kendeou, 2001; Kendeou & van den Broeck, 2007; Lipson, 1982; Peeck, van den Bosch & Kreupeling, 1982).

While many have pointed to high school and college students' lack of scientific literacy skills, however, it is clear that in order to effectively address this issue, we must address the problem at a younger age. Deficits in science for U.S. students, including scientific literacy, begin early and become more pronounced in the upper grades. Fourth graders in the U.S. ranked seventh in the 2011 Trends in International Mathematics and Science Study test (TIMSS) for Total Science score, which included a composite of Life Science, Physical Science, and Earth Science. By eighth grade, this problem becomes worse. For eighth grade students in the same year, the U.S. ranking for Total Science score (Biology, Chemistry, Physics, and Earth Science) fell from seventh to ninth (Martin, Mullis, Foy, & Stanco, 2012). As students proceed through the grades, science proficiency decreases compared to students in many other countries, making it imperative that we begin to address scientific deficits earlier than high school.

In preparing younger, middle school, students for critically evaluating online information in science, we must consider the role that individual differences play in this process. A long line of research illuminates the important roles that individual differences play in academic achievement, particularly in science and offline reading outcomes. Afflerbach (2015) points out that questions related to the effects of individual differences on reading ability "are key questions for research and practice" (page iv). The present study aims to take up this important work of investigating the effects of individual differences on reading ability by exploring the effects of group difference variables, which have important implications for individual differences in reading and evaluating during online reading in science.

In order to design effective instruction and assessment that is targeted to students' specific needs, we need to first better understand the unique effects of different individual difference variables on students' comprehension in online disciplinary areas. Therefore, to

investigate these issues, this study framed the research around three perspectives and areas of research relevant to students' ability to critically evaluate online information in science. These include: 1) theories of offline and online reading, including critical evaluation; 2) perspectives on individual differences; and 3) a disciplinary literacy framework for science.

Perspectives on Reading

Offline and online reading. The present study views reading comprehension as a process in which meaning is constructed through an interaction between reader, text, and context (RAND Reading Study Group, 2002). In this view, reading comprehension is a constructive and iterative process (Anderson & Pearson, 1984; Kintsch, 1998) in which readers use strategies to actively construct meaning as they read (Afflerbach & Cho, 2009; Langer 2011). Throughout this reading process, readers use multiple skills and strategies as well as prior knowledge to construct meaning (Baker & Beall, 2009; Kintsch, 2013; Pressley & Gaskins, 2006; Rapp & van den Broek, 2005).

In the present study, this view of reading is considered in two ways: offline reading and online reading. Here, offline reading is defined by that reading which occurs using written language forms that often are found in books and other traditionally printed materials. It is what has been studied extensively in the past (Kamil, Pearson, Moje, & Afflerbach, 2011).

Traditionally, offline reading has been considered to be a primary element, and individual differences in areas such as prior knowledge, gender, and socioeconomic status, or SES, have been viewed as secondary elements of offline reading (See, for example, Brady, Braze, & Fowler, 2011).

With the Internet, however, a somewhat different type of reading has appeared, online reading. This kind of reading has prompted some to suggest online and offline reading may not

be isomorphic (Afflerbach & Cho, 2008; Coiro & Dobler, 2007; Leu et al., 2007). Studies have shown that offline skills, such as those currently measured with state testing, are not isomorphic with online reading skills; rather, additional literacy skills appear to be required (Afflerbach & Cho, 2010; Coiro, 2011; Coiro & Dobler, 2007; Leu, Castek, & Hartman, 2006). The present study considers online reading to be the primary element and variation in offline reading ability to be an important individual difference that impacts online reading ability, just as gender and SES do.

The present study views the process of online critical evaluation, one aspect of both online reading (Leu, et al., 2013) and offline reading (Duke & Pearson, 2002) within the context of the RAND Reading Group model, where the text is a website with information in the discipline of science, the activity is the online research task in science, and the reader is using the critical evaluation of online information skills and habits of mind required for the discipline (see Figure 1). The process of critical evaluation occurs as part of the online research and comprehension process, which both shapes and is shaped by the text, the activity, and the reader(s). Finally, the online research and comprehension process occurs within a sociocultural context that includes, in this case, the disciplinary community and a collaborative learning environment, as students engage with avatar students in order to complete the research task.

Online reading and the new literacies of online research and comprehension.

Online reading typically occurs within a complex process of inquiry and problem solving as we seek answers to questions and use the Internet to comprehend and learn, almost always from informational text. The process has been defined as online research and comprehension, one of many lowercase theories of new literacies (Kingsley & Tancock, 2014; Leu, et al, 2013).

The new literacies of online research and comprehension (Leu, et al., 2013) frames online

research as a reading comprehension skill. This view suggests that at least five cognitive processing practices occur during online research and comprehension that include both traditional and new skills and strategies in five key areas: 1) reading to define important questions or problems (Leu, Kinzer, Coiro, & Cammack, 2004); 2) reading to locate information (Bilal, 2000; Guinee, Eagleton, & Hall, 2003); 3) reading to evaluate information (Sanchez, Wiley, & Goldman, 2006); 4) reading to synthesize information (Goldman, Wiley, & Graeser, 2005; Leu, et al., 2013; Jenkins, 2006); and 5) reading and writing to communicate information (Greenhow, Robelia, & Hughes, 2009). The proposed study focuses on the third area, reading to evaluate online information, by investigating seventh graders' abilities in this skill area, particularly compared to their abilities in locating, synthesizing, and communicating.

Defining important problems. When we read on the Internet, we often aim to solve a problem or answer a question, and how a problem or question is framed is a central part of online research and comprehension (Leu et al., 2013). The assessment used in the present study aimed to mirror an authentic online reading task as closely as possible. Therefore, students read to answer a specific research question that was provided for them.

Locating. Reading to locate information that fits one's needs is an important part of online reading (Leu et al., 2013; Eagleton, Guinee & Langlais, 2003; Sutherland-Smith, 2002). The process of online reading often begins with locating information, as students must first locate information before they can evaluate, synthesize, or communicate it to others. Moreover, in the context of online research, the process of locating often is intertwined with the processes of evaluating and synthesizing, since a reader might locate a different source after evaluating it and deeming it unreliable. Locating can involve using effective keyword search strategies (Bilal, 2000; Kuiper & Volman, 2008), drawing inferences about which links may be most relevant and

reliable when viewing a set of search engine results (Henry, 2006), and scanning for relevant and reliable information within websites (McDonald & Stevenson, 1996; Rouet et al., 2011).

Evaluating. In addition to being framed by a theory of online research and comprehension, this study also is framed by perspectives on critical evaluation. Research on critical evaluation has focused on several important markers of information quality, including credibility and relevance (Judd, Farrow, & Tims, 2006; Kiili, Laurinen & Marttunen, 2008). The present study focuses on credibility and defines students' ability to critically evaluate websites as being determined by the ability to evaluate two key aspects of a text: author and/or publisher credibility, and information reliability. In the present study, author/publisher credibility is defined in terms of author or publisher expertise (Bråten, Strømsø, & Britt, 2009; Judd, Farrow, & Tims, 2006; Rieh & Belkin, 1998), including author bias and point of view. Similarly, information reliability is defined in terms of author expertise and information quality (Goldman, et al., 2012; Kiili, Laurinen, & Marttunen, 2008; Sanchez, Wiley, & Goldman, 2006). The proposed study investigates how well middle school students evaluated the information they found online during a focused research task. Students were asked to investigate author and publisher credibility along with information quality at sites they read.

Synthesizing. As students read and conduct research online, they must synthesize information from multiple texts and sources (Jenkins, 2006). These texts often include various multimedia formats and tools, including email, blogs, wikis, social networks, video, hyperlinks, sound, and more. In offline reading, students are typically using just one or two formats and/or tools (text and images on a page, for example, rather than text, images and a video that needs to be clicked on within an email format). In online reading, however, students are using a nearly unlimited mix of formats and tools. As such, readers are faced with a potentially more

challenging task, as they must be able to locate, understand, and integrate information across multiple formats.

Communicating. Finally, communicating with others in order to obtain information or share what one has learned is an important part of online research and comprehension (Britt & Gabrys, 2001). As such, students often are collaborating with others in the process of online research and comprehension. Additionally, as with synthesizing information using new formats and tools, communication using new formats and tools also requires new knowledge, skills, and social practices (Coiro et al., 2008).

Perspectives On Individual Differences

Afflerbach (2015) emphasizes the idea that each student possesses a unique set of differences, all of which interact during reading development and influence reading processes and comprehension. One type of variable that influences an individual student's reading ability is an individual variable, such as a physical, cognitive, affective, or social variable. Knowledge, skills and strategies can be seen as individual difference variables that vary from student to student, with no two students having exactly the same set of knowledge, skills, and strategies. Prior knowledge is one example of an individual variable that varies from student to student and thus affects each student's reading ability to a different extent.

Group difference variables are another type of variable that influence an individual student's reading ability and that may even influence individual variables. In one sense, group difference variables can be seen as moderating variables. Gender can be one such variable. For example, reading outcomes differ by gender, with females typically performing higher on reading assessments than males (Logan & Johnston, 2010). A reader's gender interacts with other group and individual characteristics to influence a student's reading ability. While gender

is a group difference variable, then, it is part of the composite of differences that makes a student unique and influences an individual student's reading ability. As such, in the present study, gender is viewed as a group difference variable (sometimes called an individual difference variable but referred to here as a group difference variable to avoid confusion over terminology) that influences individual differences in reading within students.

In the present study, four individual difference variables, including prior knowledge, gender, socioeconomic status of the school one attends, and offline reading ability, two of which are also group difference variables, including gender and socioeconomic status of the school one attends, have implications for how we might approach individual differences in reading during instruction. As such, the present study can inform issues of individual differences in reading.

Disciplinary Literacy and Scientific Literacy

The present study uses a disciplinary literacy perspective when considering the ways in which texts and readers function. In the present study, the text is viewed as a disciplinary text from the discipline of science. In this regard, the present study draws upon a disciplinary literacy framework (Shanahan & Shanahan, 2008), which posits that literacy is characterized by the specific needs and purposes of the disciplinary knowledge base in which it operates. In other words, disciplinary literacy refers to the literacy skills that are specialized to the discipline in which they are used (Shanahan & Shanahan, 2008). In the present study, the process of meaning-making while critically evaluating in the online research and comprehension task occurs through an interaction of reader, text, and activity. In this case, the reader actively constructs meaning from a disciplinary text by drawing upon the resources of the disciplinary activity (researching a scientific topic).

The present study focuses specifically on the discipline of science. In this study, I use the term *scientific literacy* to refer to the notion of disciplinary literacy in science. In the present study, this includes what Norris and Phillips (2003) term both the “fundamental” and “derived” sense of science literacy (p. 224). The fundamental sense of science literacy is the ability to read and write in ways that are specific to the discipline of science, whereas the derived sense of science literacy refers to the general knowledge about and understanding of scientific concepts.

In the present study, I view scientific literacy within the context of both its fundamental and its derived sense, since the two senses are interdependent in Western science (Fang, 2005; Norris & Phillips, 2003). The present study therefore views scientific literacy from the perspective of functional linguistics, which recognizes language as a semiotic tool that is involved in the construction of knowledge (Halliday & Martin, 1993). The fundamental sense of science then is intimately involved in the derived sense of science and the two cannot be separated. The fundamental sense of science literacy involves the reading, writing, and evaluating that are necessary aspects of engaging with scientific text (Krajcik & Sutherland, 2010) and also of doing science. In the present study I focus on this “fundamental” sense of science literacy in a way that recognizes that this fundamental sense is intimately linked to the derived sense.

Methods and Procedures

Participants

Participants included seventh grade students who participated in Year 4 of a five-year study examining students’ online research and comprehension ability. This included students who took one of the Online Research and Comprehension Assessments II, as well as an offline

reading measure, as part of The ORCA Project (Leu, Kulikowich, Sedransk, & Coiro, 2009-2014).

Participants included a total of 1,434 students from two different states in the Northeast, with 767 students from State A and 667 students from State B. This included 736 girls and 698 boys. This also included 17 school districts in State A and 23 school districts in State B, with one school in each district. See Table 1 for additional demographic data.

Districts and schools were selected based on a sampling plan that stratified districts by socioeconomic status, geographic area, and reading comprehension ability of students. Within each school, principals and teachers then selected two heterogeneous English Language Arts classes, and all students within each class were invited to participate.

Instrumentation

Online research and comprehension assessments (ORCAs). This study used data from a set of assessments of online research and comprehension called the ORCAs, or Online Research and Comprehension Assessments (Leu et al., 2009-2014). Specifically, this study used data from the ORCA-II. The ORCA-II is an assessment that was designed as part of a five-year federal grant to assess students' ability to read and conduct research online in science (Leu et al., 2009-2014). The ORCA-II measures students' ability in four key online research and comprehension skill areas: locating, evaluating, synthesizing, and communicating information. The ORCA-II exists in two different formats, both a multiple-choice format (ORCA-MC) and a closed, virtual Internet format (ORCA-Virtual). Each student completed both an ORCA-MC and an ORCA-Virtual, on two different assessment days. For the present study, data were drawn only from the ORCA-Virtual. The ORCA-Virtual included two different life-science topics that included heart health and eye health.

Prior knowledge measure. Prior knowledge was estimated using a 10-item domain knowledge questionnaire that was related to the domain of a given ORCA-II (heart or eyes). This measure was delivered after logging into the ORCA-II but prior to beginning it.

Offline reading measure (ORM). After completing the first ORCA-II but prior to completing the second ORCA-II, students completed a pencil and paper ORM. This measure contained two passages with accompanying items. These passages and items were drawn from prior National Assessment of Educational Progress (NAEP) assessments.

Demographic data: Gender and socioeconomic status. Gender was collected from students prior to beginning the prior knowledge measure. For both states, data on socioeconomic status (SES) was collected at the school level using percent of students using free and reduced price lunches as a proxy measure of SES for the school.

Procedures

Students completed the ORCA-II (along with the prior knowledge measure and the demographic data questionnaire) on each of two different assessment days. Students were randomly assigned to two different assessment topics (energy drinks, video games, snacks, or cosmetic contact lenses) as well as to two different formats (ORCA-MC or ORCA-Virtual). Format order was randomized. Both the ORCA-IIs and the ORMs were scored by trained scorers after all of the data had been collected.

Analysis

Research question 1. The first research question investigated the online research and comprehension skill of critical evaluation in relation to three other online research and comprehension skills that included locating, synthesizing, and communicating information by exploring both its uniqueness as well as how well students performed on it compared to these

three other skills. The first research question was investigated from two different perspectives, with a different analysis for each perspective. First, an analysis of shared variance involving four separate regression analyses was used to investigate the extent to which elements found in the critical evaluation construct were also found in the locate, synthesize, and communicate constructs.

For the second approach for investigating the first research question, three separate, two-level models were used to evaluate the relative difficulty of the critical evaluation construct in relation to the Locate, Synthesize, and Communicate constructs. Each construct was measured by each of the four skill area scales (Locate, Evaluate, Synthesize, and Communicate) on the ORCA.

Research question 2. The second research question used a two-level model to investigate the extent to which prior knowledge, gender, SES, and offline reading ability contributed to students' critical evaluation abilities.

Significance of the Study

The national deficit in scientific ability, including scientific reading and writing in digital environments, is an especially acute problem given that countries rely upon new scientific understandings for progress and new technologies (National Research Council, 2007; The President's Council of Advisors on Science and Technology, 2010). While much recent national attention has focused on the need for students to learn the scientific technologies necessary for success at work (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011), as well as the scientific literacy skills necessary for scientific work (Cervetti, Pearson, Bravo, and Barber, 2005) and issues of personal importance (Brickman et al., 2012), little progress has been made.

The U.S. lags behind many other nations in studies of science achievement that measure science conceptual knowledge as well as the literacy skills necessary for conducting scientific work, including critical evaluation (U.S. Department of Education, 2012). The majority of students in the U.S. have scored below Proficient on the National Assessment of Educational Progress (NAEP) for the last two years in which assessment data was collected (U.S. Department of Education, 2012). Currently, U.S. students only score about average on the science portion of the Programme for International Student Assessment (PISA) test, an International test of 15-year-olds' competencies in reading, math, and science (U.S. Department of Education, 2012). In fact, the average score for the United States was one point below the average overall score for all countries (U.S. Department of Education, 2012). Moreover, many of the doctorate degrees that are awarded to students in science and engineering fields in the U.S. are actually awarded to non-U.S. citizens. In 2014, 37% of science and engineering doctorates were awarded to people holding temporary visas (NSF, 2014).

The U.S. also fails to prepare its students for science jobs by its own standards. Scores on the National Assessment of Educational Progress (NAEP) repeatedly show a huge deficit in science ability. In 2009, only 34 percent of students in fourth grade performed at or above proficient in Science (U.S. Department of Education, 2012), while 28 percent of students scored below basic. As we see with the TIMSS assessment, performance drops in later grades. By grade 12 for NAEP in the same year, a mere 21 percent of students scored at or above proficient and 40 percent scored at Below Basic. In 2011, when only eighth graders took the Science NAEP, still only 32 percent were at or above Proficient, and 35 percent still scored below basic (U.S. Department of Education, 2012). While the differences from 2009 to 2011 were statistically significant, the scores still represent enormous deficits in science abilities for students in the

United States.

Today's students must not only learn the traditional scientific knowledge and skills but must also learn the scientific literacy skills necessary for real scientific work (Cervetti, Pearson, Bravo, and Barber, 2005; Osborne, 2002) and must learn them within new, digital environments such as the Internet (CCSS, 2010; NGSS Lead States, 2013). Since a large part of success in these digital environments is learning critical evaluation skills, science, technology, engineering, and math initiatives have recommended that we prepare students for the new technologies they will need in the workplace by teaching critical evaluation skills (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011). This preparation is especially important with the new Common Core standards (2010), which emphasize instruction for students in discipline-specific literacies, including scientific literacies using digital sources. It is also important in the Next Generation Science Standards, which emphasize the point that "access to digital resources" and "online learning communities" (p. 38) will be key requirements for success of the implementation of the standards. The Internet has become such an important context for scientific reading and information use that President Barack Obama set and achieved a national goal of providing 98 percent of Americans with high-speed wireless Internet specifically so that scientists can access the information they need (Obama, 2015). However, little research exists to inform teachers' practice in the area of online science and, especially, critical evaluation.

Some research has indicated that many students in the U.S. do not develop the kind of knowledge and skills they need to critically evaluate scientific texts (Duschl, Schweingruber, & Shouse, 2007; National Research Council 2005, 2008). Some programs have begun to address this problem of a lack of scientific literacy skills by aiming scientific literacy interventions at

high school students. However, few have paid attention to online critical evaluation, despite the fact that this is an essential area for scientific knowledge and learning (Halverson, Siegel & Freyermuth, 2010).

Furthermore, programs aimed at improving scientific literacy do not tend to tailor instruction to meet the specific and unique needs of different types of students within an online informational environment, including the needs of students of different genders, from different economic classes, and with different cognitive skills. In science in the U.S., in particular, women are underrepresented compared to men and have lower levels of achievement (NSF, 2015). The same is true of minorities, who tend to come from lower socioeconomic backgrounds compared to non-minorities (OECD, 2015). This is highly problematic if we hope to provide an equal education to all students. In fact, both national and international attention recently has focused on helping women and minorities engage with and achieve in science (National Science and Technology Council, 2013; OECD, 2015). However, these programs are not often focused on an Internet environment. Moreover, given that we know little about individual differences in online critical evaluation, it is difficult to develop effective instructional programs without first understanding students' existing capabilities.

According to the Common Core standards, students in eighth grade are expected to be able to begin to consider their information sources when conducting research. According to the standards, eighth grade students should be able to “assess the credibility and accuracy of...multiple print and digital sources (CCSS, p. 44).” By eleventh and twelfth grade, students should be able to “assess the strengths and limitations of...multiple authoritative print and digital sources...in terms of the task, purpose, and audience.” Understanding students' capabilities in seventh grade will ensure that they can begin to develop effective evaluation habits of mind

before they enter high school, where they likely will be faced with more difficult concepts and texts. However, little research to date explores this issue, despite its importance.

The proposed study thus aims to address an issue of paramount importance by limiting the exposure of validity threats as much as possible. Despite these potential limitations, the study will provide important information to teachers and researchers. This information ultimately will benefit students by helping to build a foundation that teachers and researchers can use to develop instruction aimed at helping students learn valuable online critical evaluation skills in science necessary for success in school, work, and life. The costs of continuing to aim scientific literacy and critical evaluation studies at high school students rather than at younger students too, as well as the costs of doing so without incorporating online environments, are enormous. Those students who do not begin building scientific literacy and evaluation skills before high school will be unlikely to attain them later on.

Also, we must understand the needs and abilities of different types of students, including students of different genders and economic groups, and with different degrees of reading skills, in order to build effective instruction that is targeted to the needs of all students. Without this targeted instruction, it is unlikely that women and men, minorities and non-minorities, and students from different socioeconomic backgrounds will be equally engaged in science. Without engaging all students, we will significantly and negatively impact science and reading progress for individuals and for our country. In science in the U.S., women's and minorities' representation in science fields does not reflect their representation in the general population (NSF, 2015). If we fail to engage all students with different individual differences, we will significantly impact progress compared to other countries that are more effective at engaging all students. In the U.S., for example, we tend to see girls performing below boys in science, though

internationally, achievement tends to be more equal on average (Martin et al., 2012; OECD, 2015).

Without targeted instruction that meets the needs of all learners, it is unlikely that we will be able to serve the needs of all students equally. This is problematic in a society that aims for equality. It is also unlikely that U.S. students will be able to engage in an increasingly science-oriented world and catch up to their International peers and likely that the U.S. will be less globally competitive and have decreased intellectual and industrial progress as time goes on. These costs make it imperative that we begin to investigate the online critical evaluation abilities of middle school students in science and ultimately improve the capabilities of our nation's students in this area before they enter high school.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

This study investigated the nature of students' ability to critically evaluate online information in science in relation to three other skill areas also required during online reading in science, including locating, synthesizing, and communicating information. This study further explored the impact of four individual difference variables that included prior knowledge, gender, socioeconomic status, and offline reading ability on students' critical evaluation abilities within this science research task. Four related factors have indicated the need for this research. These factors include 1) a national and international focus on teaching students the science skills they need for life and work, which especially include scientific literacy skills 2) an increasing national and international interest in both the science and literacy fields in the context of the Internet, 3) the importance of critical evaluation skills for science, particularly within the context of the Internet, and 4) the influence of individual difference variables on students' literacy and science outcomes.

Recently, much national attention has focused on the need to prepare students to engage with science in their daily lives as well as to prepare them for future science-related jobs (NRC, 2012; National Science and Technology Council, 2013). Additionally, attention has been placed on teaching the literacy skills required for engaging with science rather than merely teaching facts and concepts (NGSS Lead States, 2013, NRC, 2012). Given that the Internet has become a key context for scientific information (Horrigan, 2006; Thomm & Bromme, 2016; Tsai, Hsui, & Tsai, 2012), teaching literacy skills within the context of the Internet has become critically important. Somewhat in parallel due to the importance of the Internet as an information space,

literacy research has focused increasing attention on the literacy skills required not just for offline contexts but also for online ones (Afflerbach & Cho, 2009; Leu et al., 2013).

A small body of emerging research has begun to converge around these three fields of science, literacy, and online reading to form the important area of online literacy in science, much of which is focused on the specific and important literacy skill of critical evaluation (see, for example, Goldman et al., 2012, Stadtler, Scharrer, Macedo-Rouet, Rouet, & Bromme, 2016; Thomm & Bromme, 2016; and Wiley et al., 2009). Despite this emerging research, however, we still know relatively little about students' abilities in this area. Meanwhile, research in offline reading and science recently has focused particular attention on the influence of individual differences on students' comprehension abilities, which has important implications for how we design instruction and assessment so that it is targeted to students' needs (see, for example, Afflerbach, 2015 and OECD, 2015).

Unfortunately, few have framed online research and comprehension in science, including critical evaluation, in a discipline-specific and online-specific way, considering the unique nature of reading and comprehending science information in online contexts. Moreover, even less work has given attention to the influence of individual difference factors on students' abilities within this specific area of online literacy in science. This is problematic if we hope to prepare students for an informational world that increasingly requires science and Internet skills. Understanding the impact of individual difference variables and thus the needs of different students is necessary for designing effective instruction, since effective instruction needs to be targeted to students' needs (Jonassen & Grabowski, 2012; Tobin & McInnes, 2008).

Moreover, both the literacy and science communities have been slow to take up this work in ways that have had large and impactful effects on students. For example, while the Common

Core's Key Design Considerations call for gathering, comprehending, evaluating, synthesizing, and reporting on information using "print and nonprint texts in media forms old and new" (CCSSO, 2016), and while the reading standards refer to the use of "digital text" throughout (CCSSO, 2010; see for example, p. 11), neither document specifically refers to the "Internet" or uses this word (Leu, Zawilinski, Forzani, & Timbrell, 2015). While it is certainly possible and important to read the Common Core standards with "a lens to the future" (Leu et al., 2015, p. 348), and assume that "new media forms" refers to the Internet, it is also possible to teach and assess according to the Common Core standards and use other media forms and even digital text that do not include the Internet. One example of this is the use of software applications, where the text is digital but does not exist in an "online" environment, in which students can connect to a nearly infinite amount of information as well as to other people through the World Wide Web.

We see a similar problem with the Next Generation Science Standards (NGSS Lead States, 2013). The term "digital" is used throughout the standards; for example, when referring to "digital tools," (p. 29) "digital media" (p. 154) and "digital sources" (p. 154). However, this document only uses the word "Internet" one time (see page 64) and does so in passing. The document suggests, in parentheses, that the Internet might be one context in which students might read scientific information. As with the Common Core standards, with this lack of attention on the specific digital context of the Internet, it is possible for teachers to teach in accordance with these science standards without ever using the Internet. This is problematic given that many have suggested that the Internet is, in fact, a key context for reading scientific information (Horrigan, 2006; Obama, 2015; Thomm & Bromme, 2016; Tsai et al., 2012).

Given the centrality of the Internet to daily and working life today, especially for science-related issues, it would be unfortunate and highly problematic if teachers taught using digital

texts without ever using the Internet. The Internet is a central context for work and life today with specific characteristics that have significantly altered the nature of literacy (Coiro, Knobel, Lankshear, and Leu, 2008; Leu et al., 2011; Leu et al., 2013). In addition to the characteristics of digital, multimedia text that we might see in digital but non-Internet spaces, such as text that occurs in a software application, the Internet has several characteristics that make it unique as an information source. The Internet is an environment in which one is connected to other people and other networks. In mere moments, individuals can connect and interact with others through many different tools, including chatting, videoconferencing, email, wikis, discussion forums, and more. Moreover, information is networked, making it fast and easy to access multiple, related texts by searching quickly or clicking on hyperlinks. In this context, individuals can access information quickly and from any physical location they wish as long as they are connected to the Internet, and they can do so while collaborating with others. As a result, networked communication and collaboration have become key aspects of the way in which we read and use information today (Engeström & Sannino, 2010; Kiili, Laurinen, Marttunen, & Leu, 2012; Leu et al., 2013). This unique information space that is the Internet has become central to daily life and work. Given this, it is puzzling and unfortunate that educators and policymakers in literacy and science fields alike sometimes skirt around this information space, referring to “digital texts” without focusing specific attention on the centrally important and unique context of the Internet.

As the Internet becomes an increasingly important information and communication context for science, especially, (Horrigan, 2008; Obama, 2015; Thomm & Bromme, 2016; Tsai et al., 2012), understanding students’ abilities in this area and the individual difference factors that influence them is key for developing assessment and instruction targeted to students’ needs. In order to prepare students for daily participation as well as for jobs in a scientific society, it is

critical that research is undertaken in this area in order to provide focused direction that can guide the development of theory, research, and practice in ways that will ensure that all students learn the skills they need to be prepared for a networked, scientific world that uses the Internet as a key context.

Theoretical Perspectives

Given the importance of the three fields of scientific literacy, online reading, and individual differences, to students and to education today, particularly in terms of how these fields intersect with one another, this study used perspectives in all three of these fields to frame the research. Labbo & Reinking (1999) suggest that a multiple realities, or multiple theoretical perspectives, approach is valuable when considering the role of technology in literacy research and instruction. Considering multiple theoretical perspectives allows one to acknowledge the influences of multiple different lenses while at the same time limiting the frame with which one views a study in a way that gives shape to it. The present study uses this idea of multiple realities to frame the study, thereby shaping and limiting its outcomes and conclusions to be more useful to research and practice.

Specifically, this study is framed by three perspectives related to students' ability to critically evaluate online information in science. These include: 1) theories of offline and online reading comprehension, including critical evaluation; 2) perspectives on individual differences; and 3) a disciplinary literacy framework for science. Together, these perspectives form the basis for a model of online reading and critical evaluation in science that framed this study. This model includes the ways in which individual differences in readers (such as prior knowledge, gender, SES, and offline reading ability) are brought to bear on the process of critically evaluating online texts in science and also the ways in which this process affects readers' ability

to evaluate the credibility of online information in science. The idea of multiple realities is particularly relevant since the Internet, as a technology, is not just imposed upon the perspectives used in the present study but is intimately interwoven with them, both affecting and being affected by the various perspectives. Thus, in this process, both the Internet and the field of science is involved in constructing the meaning of online scientific literacy.

Perspectives on Reading

Offline and online reading. The present study views reading comprehension as a process in which meaning is constructed through an interaction between reader, text, and context (RAND Reading Study Group, 2002). In this view, reading comprehension is a constructive and iterative process (Anderson & Pearson, 1984; Kintsch, 1998) in which readers use strategies to actively construct meaning as they read (Afflerbach & Cho, 2009; Langer 2011). Throughout this reading process, readers use multiple skills and strategies as well as prior knowledge to construct meaning (Baker & Beall, 2009; Kintsch, 2013; Pressley & Gaskins, 2006; Rapp & van den Broek, 2005).

In the present study, this view of reading is considered in two ways: offline reading and online reading. Here, offline reading is defined by that reading which occurs using written language forms that often are found in books and other traditionally printed materials. It is what has been studied extensively in the past (Kamil, Pearson, Moje, & Afflerbach, 2011). Traditionally, offline reading has been considered to be a primary element, and individual differences in areas such as prior knowledge, gender, and socioeconomic status, or SES, have been viewed as secondary elements of offline reading (See, for example, Brady, Braze, & Fowler, 2011).

As the Internet has grown in prevalence, however, a somewhat different type of reading has appeared, online reading, that has prompted some to suggest online and offline reading may not be isomorphic (Afflerbach & Cho, 2008; Coiro & Dobler, 2007; Leu et al., 2007). Studies have shown that offline skills, such as those currently measured with state testing, are not isomorphic with online reading skills; rather, additional literacy skills appear to be required (Afflerbach & Cho, 2010; Coiro, 2011; Coiro & Dobler, 2007; Leu, Castek, & Hartman, 2006). In online reading, new tools such as blogs, wikis, and social networks alter the nature of reading (Coiro, Knobel, Lankshear, & Leu, 2004). Afflerbach and Cho reviewed 46 studies that focused on reading strategy use during Internet and hypertext reading. Their analysis showed evidence of strategies that “appear to have no counterpart in traditional reading” (p. 217). The present investigation considers online reading to be the primary element and variation in offline reading ability to be an important individual difference that contributes to online reading ability, just as gender and SES do.

Online reading and the new literacies of online research and comprehension.

Online reading typically occurs within a richly integrated and complex process of inquiry and problem solving as we seek answers to questions and use the Internet to comprehend, learn, and communicate with others about what we have learned. This process almost always involves learning from informational text rather than literary text and has been defined as online research and comprehension, one of many lowercase theories of new literacies (Kingsley & Tancock, 2014; Leu, et al, 2013)

The new literacies of online research and comprehension (Leu, et al., 2013) frames online research as a reading comprehension skill. This view suggests that at least five cognitive processing practices occur during online research and comprehension that include both

traditional and new skills and strategies in five key areas: 1) reading to define important questions or problems (Leu, Kinzer, Coiro, & Cammack, 2004); 2) reading to locate information (Bilal, 2000; Guinee, Eagleton, & Hall, 2003); 3) reading to evaluate information (Sanchez, Wiley, & Goldman, 2006); 4) reading to synthesize information (Goldman, Wiley, & Graeser, 2005; Leu, et al., 2013; Jenkins, 2006); and 5) reading and writing to communicate information (Greenhow, Robelia, & Hughes, 2009). The proposed study focuses on the third area, reading to evaluate online information, by investigating seventh graders' abilities in this skill area. However, it does so by viewing critical evaluation within the context of an online research and comprehension task that included locating, synthesizing, and communicating.

Defining important problems. When we read on the Internet, we often aim to solve a problem or answer a question. Therefore, how a problem or question is framed is a central part of online research and comprehension (Leu et al., 2013). The assessment used in the present study aimed to mirror an authentic online reading task as closely as possible, so students read to answer a specific research question. However, it should be noted that in the present study, the problem was defined for students.

Locating. Reading to locate information that fits one's needs is an important part of online reading (Leu, Kinzer, Coiro, & Castek, and Henry 2013; Eagleton et al., 2003; Sutherland-Smith, 2002). Once a problem has been defined, locating information is often the first step in the online reading process, as students must first locate information before they can evaluate, synthesize, or communicate it to others. Moreover, in the context of online research, the process of locating often is intertwined with the processes of evaluating and synthesizing, since a reader might locate a different source after evaluating it and deeming it unreliable. Even if a reader finds a source that is reliable, the reader may locate additional sources to corroborate what she

has found or to gain an additional point of view that helps her determine a more complete picture of the information she is seeking. Locating can involve using effective keyword search strategies (Bilal, 2000; Kuiper & Volman, 2008), drawing inferences about which links may be most relevant and reliable when viewing a set of search engine results (Henry, 2006), and scanning for relevant and reliable information within websites (McDonald & Stevenson, 1996; Rouet et al., 2011).

Evaluating. In addition to being framed by a theory of online research and comprehension, this study also is framed by perspectives on critical evaluation. Research on critical evaluation has focused on several important markers of information quality, including credibility and relevance (Judd, Farrow, & Tims, 2006; Kiili, Laurinen & Marttunen, 2008). However, this study focuses on the former marker of information quality, that of credibility. This study defines students' ability to critically evaluate the information found at websites as being determined by the ability to evaluate two key aspects of a text: author and/or publisher credibility (source credibility), and information credibility. In the present study, author/publisher credibility is defined in terms of author or publisher expertise (Bråten, Strømsø, & Britt, 2009; Judd, Farrow, & Tims, 2006; Rieh & Belkin, 1998), including author bias and point of view. Information credibility is defined in terms of information quality, or the extent to which the information is accurate (Goldman, et al., 2012; Kiili, Laurinen, & Marttunen, 2008; Sanchez, Wiley, & Goldman, 2006). The proposed study investigates how well middle school students evaluated the credibility of the information they found online during a focused science research task. Students were asked to investigate both the author and publisher credibility at sites they read as well as the quality of the information at those sites.

Synthesizing. As students read and conduct research online, they must be able to synthesize

information from multiple texts and sources (Jenkins, 2006). These texts often include various multimedia formats and tools, including email, blogs, wikis, social networks, video, hyperlinks, sound, and more. Whereas in offline reading students are typically using just one or two formats and/or tools (text and images on a page, for example, rather than text, images and a video that needs to be clicked on within an email format), in online reading, students are using a nearly unlimited mix of formats and tools. As such, readers are faced with a potentially more challenging task, as they must be able to locate, understand, and integrate information across multiple texts and formats.

Communicating. Finally, communicating with others in order to obtain information or share what one has learned is an important part of online research and comprehension (Britt & Gabrys, 2001). In the online research and comprehension process, students often are collaborating with others. Additionally, as with synthesizing information using new formats and tools, communication using new formats and tools also requires new knowledge, skills, and social practices (Coiro et al., 2008).

Perspectives On Individual Differences

Afflerbach (2015) emphasizes the idea that each student possesses a unique set of differences, all of which interact during reading development and influence reading processes and comprehension. One kind of variable that influences an individual student's reading ability is an individual variable, such as a physical, cognitive, affective, or social variable. Knowledge, skills, and strategies can be viewed as cognitive individual difference variables that vary among students, with no two students having exactly the same set of knowledge, skills, and strategies. Prior knowledge is one example of an individual variable that varies from student to student and thus affects each student's reading ability to a different extent.

Group difference variables are another kind of variable that influence an individual student's reading ability and that may even influence individual variables. In one sense, group difference variables can be seen as moderating variables. Gender can be viewed as one such variable. For example, reading outcomes differ by gender, with females typically performing higher on reading assessments than males (Logan & Johnston, 2010). A reader's gender interacts with other group and individual characteristics to influence a student's reading ability. While gender is a group difference variable, then, it is part of the composite of differences that makes a student unique and influences an individual student's reading ability. As such, in the present study, gender is viewed as a group difference variable (sometimes called an individual difference variable but referred to here as a group difference variable to avoid confusion over terminology) that influences individual differences in reading within students.

The present study investigated four individual difference variables, including prior knowledge, gender, socioeconomic status of the school one attends, and offline reading ability, two of which are also group difference variables, including gender and socioeconomic status of the school one attends. In offline reading, and in some more recent online reading research, these individual difference variables have been shown to have an influence on readers' comprehension. As such, this research has implications for how we might approach individual differences in reading during instruction. The present study extends this conversation by informing issues of individual differences in reading in an online context, and specifically in regards to one important area of online reading, that of critical evaluation.

Disciplinary Literacy and Scientific Literacy

Disciplinary literacy. The present study uses a disciplinary literacy perspective when considering the ways in which texts, readers, activities, and contexts function together. In the

present study, the text is viewed as a disciplinary text from the discipline of science. In this regard, the present study draws upon a disciplinary literacy framework (Shanahan & Shanahan, 2008), which posits that literacy is characterized by the specific needs and purposes of the disciplinary knowledge base in which it operates. In other words, disciplinary literacy refers to the literacy skills that are specialized to the discipline in which they are used (Shanahan & Shanahan, 2008). In the present study, the process of meaning-making while critically evaluating in the online research and comprehension task is viewed as occurring through an interaction of reader, text, and context. Here, the reader actively constructs meaning from a disciplinary text by drawing upon the resources of the disciplinary activity (in this case, researching a scientific topic).

Scientific literacy. One discipline that has become a priority in education in the United States is that of science (National Science and Technology Council, 2013). The present study focuses specifically on this discipline. The discipline of science often is described as having importance for education in two different but related ways: personally and societally. Personally, all students need to understand basic scientific concepts so they can engage in personal issues relating to science. Societally, while it is not logical to prepare all students to become scientists, we should prepare all students to have the opportunity to become scientists if they wish to do so in order to work on issues facing the world (see, for example, DeBoer, 2007; Jones, Wheeler, & Centurino; OECD, 2013). The present study assumes these dual goals of science education.

First, regarding the goal of personal engagement with science, science affects people's daily, personal lives, since people need to engage with basic scientific information in order to understand issues of personal importance, such as medical questions or figuring out what kind of foods to feed their children or to eat themselves. For example, people often access scientific

information on the Internet in order to help them make health-related decisions (Morahan-Martin, 2004; Stadtler & Bromme, 2008) or to gather information about science-related controversies (Zeidler, 2009).

Second, regarding the societal goal of science engagement, science is necessary societally for solving many pressing problems in the world right now, such as climate change, creating better medicines and treatments for diseases such as cancer, combatting harmful bacteria, engineering new technologies, and feeding a rapidly expanding world population (Birch, Looi, & Stuart, 2013). This means that for people who become scientists and work on addressing societal problems such as these, science is important to their working lives as well as their personal ones. Given the importance of science both personally and societally, educators have become increasingly focused on preparing students by teaching them the skills they need in order to engage with scientific issues such as these.

Rather than viewing these two educational goals dichotomously, the present study attempts to resolve this tension by viewing these two potential goals of science education (engagement in personal science issues and engagement in societal science issues) along a continuum in which they work in conjunction with one another (see, for example, curriculum models that have attempted to resolve this tension, such as Millar, 2006). While we can acknowledge that the aim of K-12 science education is not to make all students grow up to be scientists, we can, at the same time, prepare students to be citizens of science, or to engage with science in more personal ways. While we prepare students to be citizens of science, we can provide students the opportunity for science careers by helping them develop initial tools for doing science, should they choose to become scientists later in their educational career. In this way, personal engagement with science is viewed at one end of a continuum of engagement with

science, which has, at its other end, engagement with science on a societal level. Thus, we can view the dual goals of K-12 science education to be those of giving all students the *opportunity* to become scientists, as well as having students become, at a minimum, citizens of science.

Another tension in scientific education centers around teaching students scientific *content*, or the knowledge they need to understand scientific issues, versus teaching students scientific *practices*, or the ways in which students engage with this content. The present study assumes that content and practices are intimately linked to one another in ways that are distinct from but also dependent upon one another. Therefore, in this study, I use the term *scientific literacy* to refer to both content and practices. This perspective is grounded in disciplinary literacy and is present in many current and prominent curricular frameworks, such as the NGSS Standards (NGSS Lead States, 2013), the K-12 Framework for Science (National Research Council, 2012), as well as many national and international assessments, such as NAEP (N.A.G.B., 2011), TIMSS (Lee, Wheeler and Centurino, 2013), and PISA (OECD, 2013).

In the present study, the notion of *scientific literacy* thus includes what Norris and Phillips (2003) term both the “fundamental” and “derived” senses of science literacy (p. 224). The derived sense of science literacy refers to the general knowledge about and understanding of scientific concepts, whereas the fundamental sense of science literacy is the ability to read and write in ways that are specific to the discipline of science. In the present study, I view scientific literacy within the context of both its fundamental and derived senses, since the two senses are interdependent in Western science (Fang, 2005; Norris & Phillips, 2003). The present study therefore views scientific literacy from the perspective of functional linguistics, which recognizes language as a semiotic tool that is involved in the construction of human experience and thus in the construction of knowledge (Halliday & Martin, 1993). The field of science as it

exists in Western science is intimately shaped by the language of science. Thus, the fundamental sense of science is necessarily involved in the derived sense of science and the two cannot be separated. The fundamental sense of science literacy involves the reading, writing, and evaluating that are necessary aspects of engaging with scientific text (Krajcik & Sutherland, 2010) and also of doing science. In the present study I focus on this “fundamental” sense of science literacy in a way that recognizes and assumes that this fundamental sense is intimately linked to this derived sense. In the present study, scientific inquiry is viewed as the goal of science education and scientific literacy is viewed as a way of engaging with that inquiry (Pearson, Moje, & Greenleaf, 2010).

Echoing Halliday & Martin (1993), Pearson et al. (2010) make the important point that reading and writing in science can and should be used to advance scientific inquiry in a way that “situate(s) literacy and science each in the service of the other” (p. 463). Scientific knowledge is, in other words, constructed through discourse and vice versa; one cannot exist without the other (Hand et al., 2003). As a result, scientific literacy is not just an important part of the science classroom; rather, it is fundamental – the field of science, and thus the science classroom, cannot and does not exist without it. Teaching science well then is not just a matter of learning how to teach the scientific literacy skills fundamental to the discipline; rather, science cannot be taught without teaching these skills. The present study thus conceives of science, science literacy, and science education in this sense.

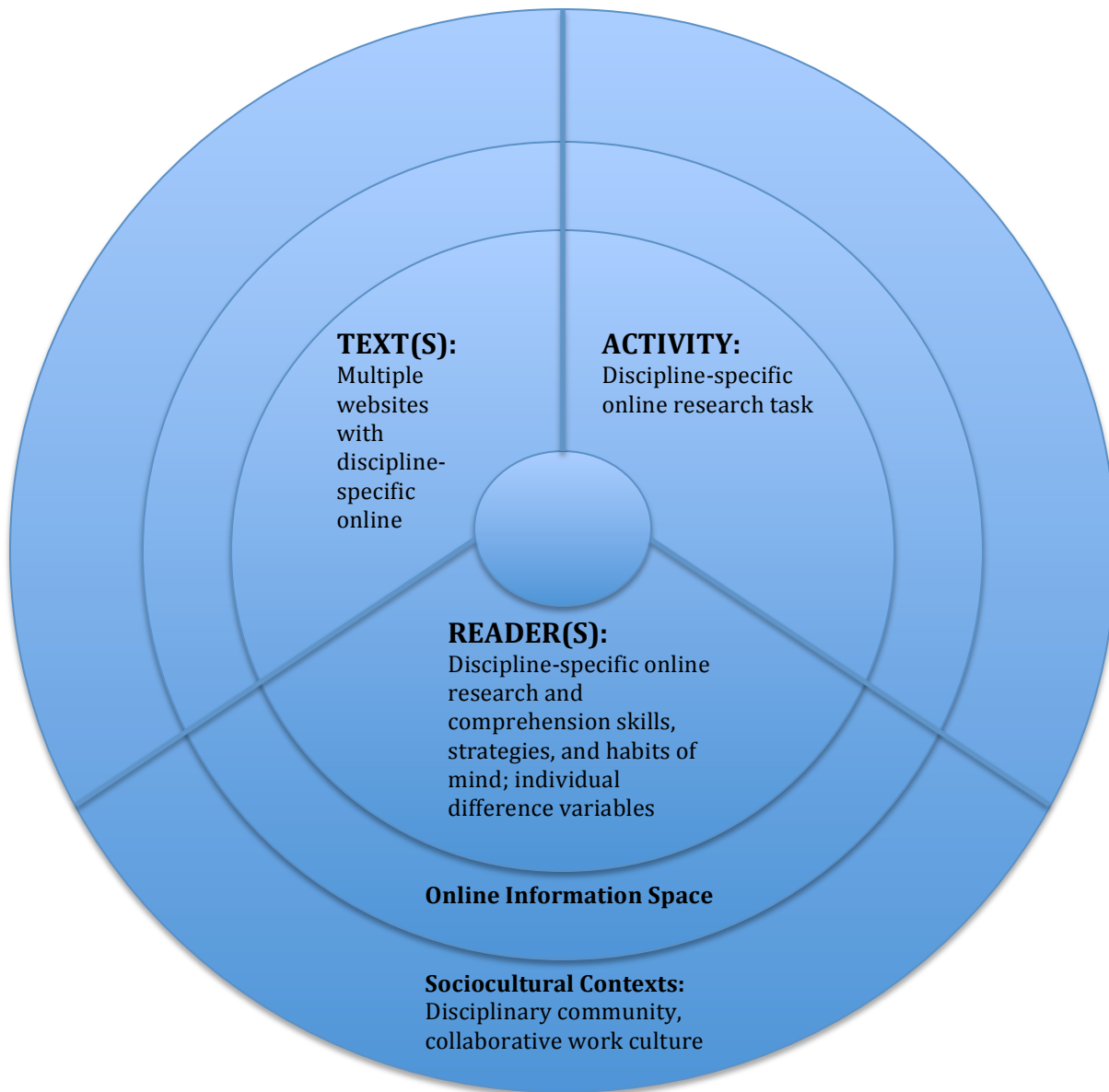
Integrating the Perspectives

The present study views discipline-specific online reading, including critical evaluation, from the perspective of: 1) a theory of online research and comprehension (Leu et al., 2013), 2) perspectives on individual differences (Afflerbach, 2015), and a disciplinary literacy perspective

(Shanahan & Shanahan, 2008). From a disciplinary literacy perspective and within the context of the RAND Reading Study Group (2002) model, online scientific literacy, and the critical evaluation of online information in science, involves the interactions of texts, readers, and activity that include the greater contexts specific to the science community and the Internet. As such, the present study considered the ways in which texts, readers, activities, and contexts related specifically to the discipline of science particularly with regards to online reading and critical evaluation (see Figure 2.1).

The present study views the process of online critical evaluation, one aspect of both online (Leu, et al., 2013) and offline reading (Duke & Pearson, 2002) within this framework, where the texts are websites with information in the discipline of science, the activity is the online research task in science, and the readers, influenced by individual difference variables, are using the critical evaluation of online information skills and habits of mind required for the discipline. The process of critical evaluation occurs as part of the online research and comprehension process, which both shapes and is shaped by the texts, the activity, and the readers. Finally, the online research and comprehension process occurs within a sociocultural context that includes, in this case, the disciplinary community and a collaborative learning environment, as students engage with avatar students in order to complete the research task.

Figure 2.1. A Framework for the Process of Critically Evaluating and Constructing Meaning During a Discipline-specific Online Research and Comprehension Task



Prior Research

In addition to being framed by perspectives in offline and online reading; individual differences; and disciplinary literacy, this study was also informed by three areas of research that included the following: 1) online reading focusing on critical evaluation, 2) scientific literacy focusing on critical evaluation and 3) individual differences in reading and science related to a) prior knowledge, b) gender, c) socioeconomic status, and d) offline reading ability.

Online Research and Comprehension

A growing body of theory and research suggests that online reading may not be the same as offline reading (Afflerbach & Cho, 2009; Coiro, 2011; Leu et al., 2013). While some research has found that offline reading ability contributes to online reading ability (Coiro, 2011), this research shows that other factors also play a significant role in students' ability to comprehend online texts. Online texts have structures and features that differ in some ways from offline texts (Coiro & Dobler, 2007). The Internet context thus places demands on readers that differ from those of an offline reading context (Afflerbach & Cho, 2009). Indeed, recent research suggests that the skills and strategies required to read and comprehend offline texts may not be sufficient for reading in an online environment (Afflerbach & Cho, 2000; Coiro & Dobler, 2007).

The research on online reading comprehension suggests that the process of online research and comprehension could be conceived of as having three separate but iterative steps a reader takes that include: 1) Constructing a set of texts, 2) Making meaning from this set of texts, and 3) Drawing conclusions from this set of texts. In the unbounded and unrestricted information space that is the Internet, readers need to construct their own pathways and make decisions throughout the reading and research process about the relevancy, accuracy, and usefulness of multiple online texts (Coiro & Dobler, 2007). Readers ultimately have to decide which texts to

use and which not to use as they draw inferences about the answer to their research question in a recursive process (Coiro & Dobler, 2007). Throughout this process, readers draw on a core set of strategies that involve locating information, evaluating it, synthesizing it (Afflerbach & Cho, 2009; Cho, 2014; Leu et al., 2013), and communicating with others about it (Leu et al., 2013). As proficient readers use this core set of skills and strategies, they self-monitor their engagement with these strategies in order to help shape this process in an effective way (Coiro & Dobler, 2007; Kiili, Laurinen, & Marttunen, 2009).

Below, I briefly outline the relevant research in online reading comprehension using the Rand Reading Study Group model (2002), which includes text, reader, activity, and context, as an organizing frame. In this framework, self-regulation and the specific core strategies involved in online research and comprehension of locating, synthesizing, communicating, and evaluating (Leu et al., 2013) are viewed as reader skills and strategies that are shaped by and help to shape the texts, activity, and contexts as readers construct a set of texts, make meaning from this set of selected texts, and draw conclusions from this text set. Thus, the section below is organized by describing online texts, online readers, and online activities and contexts, particularly as they differ from those of offline text and as they are illustrated in Figure 2.1.

Online texts. Online text appears to differ in some ways from offline text in regards to type, features, and the context of the information space. These text types and features influence the reading and research process and therefore should be considered when thinking about the process of online research and comprehension.

Online text types. Many types of online texts are specific to the affordances of an online environment. However, a lack of uniform standards regarding text type has resulted in many different types of online documents (Britt & Gabrys, 2001; Rouet, Ros, Goumi, Macedo-Rouet,

and Dinet, 2011) and thus new challenges for readers. Online text types include informational websites (Coiro & Dobler, 2007), blogs, wikis, news articles, and discussion boards (Coiro et al., 2015). Of these, only news articles are found in an offline environment. However, news articles in an offline environment differ in some ways from those found in an online environment. These new text types present new challenges for readers as they read on the Internet.

Online text features. Online texts also contain specific features not found in offline environments. These include hyperlinks (Coiro & Dobler, 2007), search engines (Coiro & Dobler, 2007), small pieces of disparate text, such as search engine results (Coiro & Dobler, 2007), advertisements (Fabos, 2008), URLs, interactive diagrams (Coiro & Dobler, 2007), and videos (Coiro & Dobler, 2007). Texts are often commercially biased and contain hidden messages that authors and publishers want to convey to their readers (Flanagin & Metger, 2010; Thoman & Jolls, 2005). As with the new text types of an online environment, these new text features present new challenges to readers as they learn how to interact with and use them most effectively.

Online activities and contexts. The online information space also presents new challenges to readers. An online environment is an open-ended information space that contains a nearly unlimited number of texts from which readers must choose when engaged in a reading task (Coiro & Dobler, 2007). Moreover, not all of these texts are of the same quality. Anyone may publish what they wish online without necessarily having to undergo a vetting process as they do in an offline environment. Readers are therefore likely to encounter many texts in this environment that lack credibility (Goldman et al., 2012). Given the challenges that readers often face with new text types and features in an online environment, there is a need for research that

explores readers' use of the core strategies within such an environment, and particularly within different disciplinary areas.

Online readers. Research in online reading suggests that reading offline and reading online may not be isomorphic (Leu, 2007). Rather, recent research suggests that while readers' offline reading ability contributes in a significant way to their reading ability (Afflerbach & Cho, 2009; Coiro, 2011), readers' offline reading ability alone is not sufficient to explain readers' online reading ability. Rather, some new skills and strategies are required to read well in an online environment (Afflerbach & Cho, 2009; Coiro & Dobler, 2007). For example, in a study of good Internet readers, Cho (2014) found that about 75% of the strategies these readers used involved those that would be used in an offline environment as well. These strategies were categorized according to Afflerbach & Cho (2009) as the following: Meaning-making, Self-monitoring, and Information Evaluation. However, about 25% of the strategies used by the good online readers were unique to an online environment and were categorized as Locating (Afflerbach & Cho, 2009) strategies.

In addition to new skills and strategies being required by online reading, some skills and strategies that have traditionally been used in an offline environment may be used in modified ways in an online environment (Cho, 2014; Coiro, 2011). For example, in an offline environment, readers may or may not engage in the planning and prediction necessary for selecting texts to read, while in an online environment, these skills become "compulsory" (Coiro & Dobler, 2007; p. 242). In this way, it appears that in an online environment, readers may need to engage in skills and strategies that are, in some ways, different or more important than those required by reading in an offline environment. As readers construct a text set, make meaning from this text set, and draw conclusions from these texts, they engage in locating, evaluating,

synthesizing, and communicating in ways that appear to both overlap with offline reading processes and extend and complicate offline reading processes.

Much research from different areas shows that effective readers self-monitor as they engage in these different strategies and in the search for online information (Afflerbach & Cho, 2014; Brand-Gruwel et al., 2005; Coiro & Dobler, 2007). This self-monitoring process helps readers achieve their goals (Stadtler & Bromme, 2007). As they read, proficient readers repair their understanding and keep themselves on track with the research task (Coiro & Dobler, 2007; Kiili et al., 2009). Given the diverse information space of the Internet, readers need to be flexible in order to shift between various text types (Eagleton & Dobler, 2007; Rouet, 2006).

Thus, skilled online readers are what Kiili, Laurinen, & Marttunen (2009) call “metacognitively competent.” In their study of 25 secondary students in Finland, they found that skilled online readers used high degrees of self-monitoring. For example, in their study, skilled online readers evaluated the effectiveness of their search strategies and changed their strategy immediately in order to produce a more effective search. Interestingly, they found that poorer online readers engaged in a greater degree of self-monitoring at the micro level (i.e., identifying the tasks the reader is doing or will do next) compared to the macro level (i.e., evaluating their strategies to fit the needs of the entire task). The researchers theorized that too much self-regulation may have used much of the readers’ cognitive capacity, leaving the readers with less cognitive capacity for reading, synthesizing, evaluating, and communicating information. This suggests that successful online readers may engage in a “just right” amount of self-regulation that allows them to focus on the core strategies of locating, synthesizing, communicating, and evaluating.

Below, I outline the ways in which readers of online text engage in these core strategies as they 1) construct a text set, 2) make meaning from that text set, and 3) draw conclusions from the text set. The section below is arranged according to these three steps in an attempt to productively frame the array of research in online reading. Focusing on the steps involved in the process of online reading and research as a frame for the skills and strategies readers must use while engaging in these steps may be a productive way for educators, students, and researchers to think about online research and comprehension since the skills and strategies necessary for this process occur throughout the reading and research process rather than in sequence. Using the three steps in the online reading and research process as an organizing tool for presenting the research may be productive for two reasons; the first is useful for theory and the second for practice. First, this is a useful way to bring together the existing research in online reading, since it considers several different factors at work in the online research and comprehension process but organizes them under the single umbrella of the process readers must use as they engage in online reading and research. Second, organizing the research by the steps involved for readers may be a valuable way for readers and educators to think about online research and comprehension since they can use this defined process to move through the cycle of online research and comprehension.

1. *Constructing a text set.* Much research in online reading suggests that one important aspect of the process of online reading is constructing a set of texts to read (Afflerbach & Cho, 2009; Coiro & Dobler, 2007; Leu et al., 2013). This process involves locating, evaluating, synthesizing, and communicating information. However, it may more heavily rely on locating and evaluating at this early stage of the research process. In an online environment, readers are faced with an unrestricted and unbounded information space (Coiro & Dobler, 2007) that

contains multiple, diverse texts with varying features and structures (Eagleton & Dobler, 2007). These texts are of different degrees of relevancy, usefulness, and credibility (Goldman et al., 2012). They also vary widely in terms of publication date, or currency, with some texts being very old and some very new.

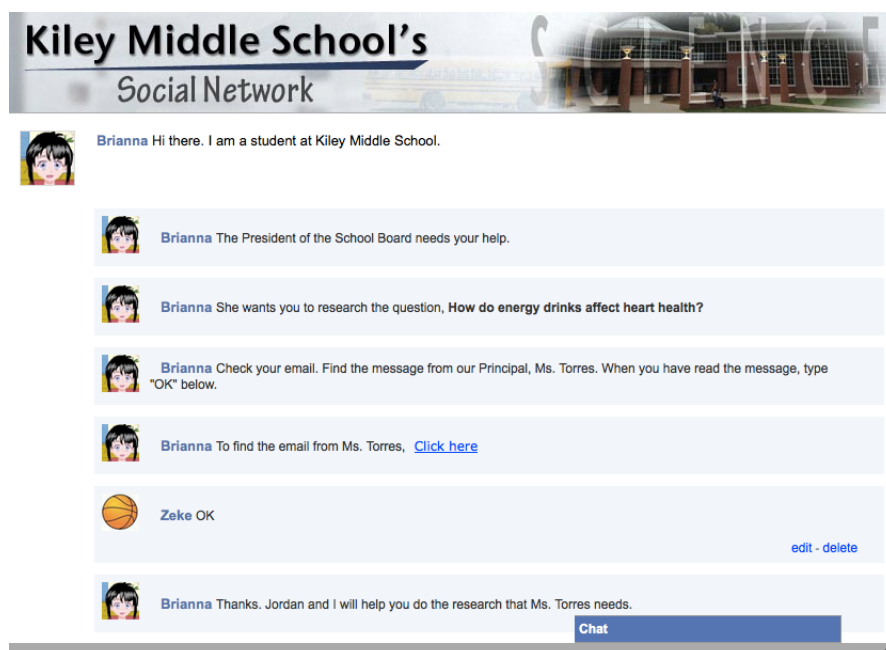
Locating texts. Throughout the process of constructing a set of texts to use in response to a research task, a proficient reader makes decisions about how best to access information. For example, a reader must know how to query search engines effectively and obtain a set of useful search results (see, for example, Sormunen & Pennanen, 2004; Zhang & Duke, 2008). Some research has found that this initial locating process acts as a “gatekeeping skill” (Henry, 2006) that can inhibit the success of the rest of the reading and research process if students are not skilled at it (Kiili, Laurinen, & Marttunen, 2008; Walraven, Brand-Gruwel, & Boshuizen, 2008).

Evaluating information. Once a reader obtains a set of useful (i.e., relevant and credible) search results, the reader must understand how to use these results effectively (Henry, 2006). For example, effective readers are able to make forward inferences, or predictions, about the kinds of websites that might be relevant and credible for their research task based reading a set of search results (Kiili et al., 2009; Coiro & Dobler, 2007). It is important to note that, in this way, locating and inferencing are important aspects of the evaluation process, particularly at the earlier stage of the text selection cycle. At this stage, the reader makes an initial prediction about which website(s) might be the most valuable (i.e., the most relevant and credible) for the research task. Once a reader has selected a website from a set of search results, he or she must navigate to the actual page and then evaluate the credibility of information at the webpage in order to determine whether or not to use the information to inform the research task (Goldman et al., 2012).

Synthesizing information within and across texts. This process often happens in conjunction with reading and synthesizing the information at the website and helps the reader further refine his or her thinking about whether to include a given website text in the active text set. As readers locate, synthesize, and evaluate the texts to determine which texts to use, they are actively constructing a set of texts that they will ultimately use as information sources that inform their response to their research topic (Coiro & Dobler, 2007). However, this process may make reading online more difficult than offline reading. For example, one study of hypertext reading found that making decisions about what to read and in what order increased the cognitive load of readers (DeStefano & LeFevre, 2007). In this way, constructing a set of texts to read online may present new challenges to readers compared to constructing a set of texts in an offline environment.

Communicating and collaborating using information. Some research and theory concerning the process of online research and comprehension has framed online reading as a collaborative, social practice rather than an individual one (Engeström & Sannino, 2010; Kiili, Laurinen, Marttunen, & Leu, 2012; Leu et al., 2013). Indeed, in recent years, work in school and workplaces has shifted from individual to collaborative. Today, work and school tend to require collaborative problem solving (PIAAC Expert Group on Problem Solving in Technology-Rich Environments, 2009; Theisens, Roberts, & Istance, 2010). As a result, there has been increasing focus on communication and collaboration in school curriculums such as the Common Core State Standards Initiative (CCSSO, 2010).

Figure 2.2. A Student Collaborating With An Avatar in the ORCA Social Networking Environment



In science, collaboration and communication is especially important and is a central aspect of scientific culture. Scientists work together to gather information and investigate problems, and they value the different skills and perspectives that different individuals can bring to a problem-solving task. Scientific arguments tend to be formulated through collaborative teams that work together to gather information, vet it, and refine it over a period of time (Cope, Kalantzis, Abd-El-Khalick, & Bagley, 2013). Thus, collaborative approaches to online reading in science may be especially valuable to educators and students since such an approach is likely to align well with the skills and strategies students will need for college and the workplace, particularly in science fields. In the present study, students worked within a social networking environment along with avatars (school leaders and other students) to locate information and conduct research (see Figure 2.2). Avatars guided students to search for particular information

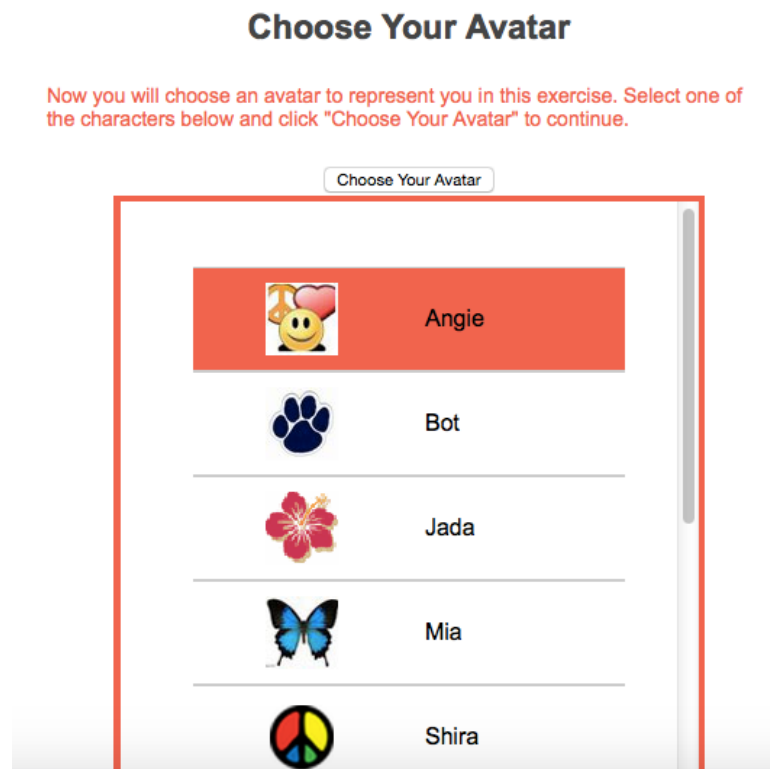
or, in some tasks, provided names of specific articles for students to find. If students were unable to locate the articles on their own, the avatars provided links to the articles.

2. *Making meaning from the working text set.* Once a reader selects a text that he or she deems valuable to the research task, the reader reads it, synthesizes this text with other texts and with his or her own prior knowledge (Coiro & Dobler, 2007), and draws inferences. As readers read, they synthesize information within and across multiple texts, comparing it to their prior knowledge and to other texts (Cho, 2011; Coiro & Dobler, 2007; Wiley et al., 2009; Le Bigot & Rouet, 2007). As they do so, they determine which texts are credible and should be used to inform their understanding of the research topic. Readers communicate and collaborate with others throughout this process as they determine how to frame their research topic in order to develop a search strategy, search for and evaluate texts, synthesize, and draw conclusions.

Locating and evaluating. When readers determine that texts are not relevant or credible, they return to their search results or even start a new search, locating additional webpages and beginning the process again (Coiro & Dobler, 2007). When readers determine that texts are relevant and credible, they keep these texts in their working text set and return to their search results to locate additional texts to further confirm their thinking (Coiro & Dobler, 2007).

Synthesizing within and across multiple texts. In an online environment, making meaning from text often involves synthesizing within and across multiple texts (Cho, 2011; Wiley et al., 2009; Le Bigot & Rouet, 2007). This process requires readers to investigate the ways in which different texts inform or contradict one another (Cho, 2011; Castek & Coiro, 2010). Moreover, after reading a webpage, a proficient reader evaluates the extent to which the information is credible (Cho, 2014; Goldman et al., 2012).

Figure 2.3. The Avatar Selection Screen At the Beginning of the ORCA



Communicating. During the making-meaning phase of online research and comprehension, readers use communication and collaboration to develop their understanding of information and evaluate it. For example, some research in online reading has shown that a collaborative approach to online reading and research can help students develop a greater array of strategies (Coiro, Castek & Guzniczak, 2011; Kiili et al., 2012) and better comprehend texts than when reading online information independently (Coiro, Guzniczak, Castek & Bradshaw, 2011). In one study of collaborative online reading, a majority of students reported that collaboration was helpful for evaluating the usefulness of information (Kiili et al., 2012). In this way, communication and collaboration are important aspects of constructing meaning during online research and comprehension. In the present study, students first selected their own avatar

(see Figure 2.3) and then worked with other student avatars to problem-solve around the provided research task and to present a response through an online communication tool that included either a wiki or an email message.

3. *Drawing conclusions from the text set.* Research in online reading suggests that after reading and evaluating each text, a proficient reader determines whether to add a text to his or her working text set, which the reader then uses to form a response to the research task (Coiro & Dobler, 2007). If the text is added to the reader's active text set, the reader uses this text as one source in forming conclusions about the research task.

Synthesizing, evaluating, and locating. At this third stage of online research and comprehension, the reader must look at all of the information as a whole and investigate the ways in which the different texts inform or contradict one another (Cho, 2011; Castek & Coiro, 2010). In this way, the proficient reader makes a final evaluation about the credibility of the texts within his or her active text set. At this stage, proficient readers are able to draw inferences from credible texts that inform their understanding of the research task (Goldman et al., 2012; McVerry, 2013) and then synthesize these inferences across multiple texts (Cho, 2011; Wiley et al., 2009; Le Bigot & Rouet, 2007). Locating may be used to a small degree at this stage if readers determine that they need to locate additional texts to clarify or deepen their understanding.

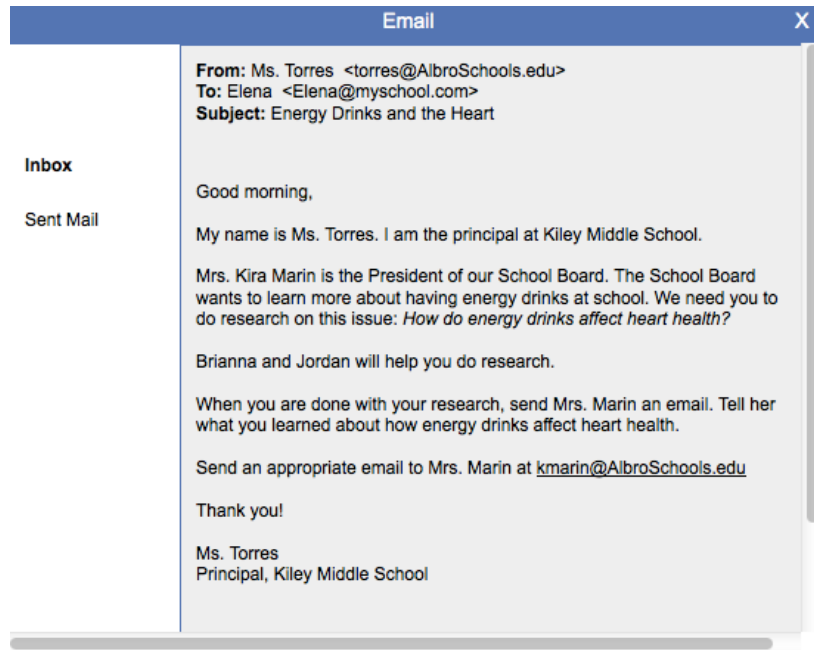
Synthesizing and communicating. Research indicates that proficient online readers synthesize the information they have found into coherent and structured responses which are communicated to others by presenting information in ways that help them accomplish further goals (Brand-Gruwel, Wopereis, & Vermetten, 2005; Britt & Gabrys, 2001). For example, a reader who wishes to be an active participant in her cancer treatment might conduct research

about different treatment options and communicate her findings to her doctor as they determine together the best course of treatment. In the present study, students learned about their research task through an email from a fictional school principal (see Figure 2.4). The student is asked by the principal to conduct research and to then use an online communication tool (either a wiki or an email) to respond to the research question.

In this way, locating, evaluating, synthesizing, and communicating are core strategies that are used iteratively throughout the online research and comprehension process, with perhaps greater emphasis placed on locating and evaluating in the former part of the process and greater emphasis on synthesizing and communicating in the latter part of the process. A growing body of research on online reading shows that good online readers are able to self-regulate their use of these strategies in a way that aligns with the research task and their reading goals (Coiro & Dobler, 2007; Kiili et al., 2009). This results in a greater likelihood that these readers will learn accurate information about their research topic compared to their less proficient peers.

In the present study, readers were asked to use these core strategies of locating, synthesizing, evaluating, and communicating for online research and comprehension throughout the research process in the iterative way described above (Leu et al., 2013). Few studies to date have examined readers' ability to critically evaluate within the context of a performance-based assessment where readers have to engage in all of these core processes in such an iterative way. The present study therefore seeks to investigate students' abilities in the important core process of critical evaluation within this context and within the discipline of science using a valid and reliable instrument.

Figure 2.4. The Email Message Defining the Research Task in the ORCAs



Critical Evaluation

Given the centrality of the critical evaluation construct in the present study, this research review focused particular and extended attention on the core online reading strategy of critical evaluation. The research review also placed some attention on critical evaluation in relation to location, synthesis, and communication.

Defining critical evaluation. The present study defines critical evaluation as a process of evaluating the extent to which information is relevant and credible, but focuses attention on the latter aspect of credibility. Different bodies of research, including research on critical reading, critical thinking, and critical literacy, define critical evaluation in different ways. However, these perspectives all share in common the notion of credibility (McVerry, 2013). According to Judd, Farrow & Tims (2006), credibility refers to the expertise and trustworthiness of the source of the information. The authors draw upon Tseng & Fogg's (1999 as cited in Judd, Farrow & Tims, 2006) notion that, in most cases, "believability" is a useful way to think about credibility.

This includes the accuracy, or reliability of the information (Kiili, et al, 2008). The more credible a source is, the more likely it is to contain accurate information. The present study focused on this definition of credibility. That is, in order for a website to be deemed credible in the online research and comprehension assessment used in this study, it had to contain information that was accurate.

Information credibility. The present study views the notion of information credibility as having three main components: 1) the credibility of the information itself (what is here referred to as *knowledge claim credibility* and what we can think of as “primary” credibility), 2) the credibility of the source of the information (what is here referred to as *source credibility* and what we can think of as “secondary” credibility), and 3) the credibility of the context of the information (what is here referred to as *context credibility* and what we can think of as “tertiary” credibility).

Knowledge claim credibility refers to the extent to which the information claims are credible. This includes the extent to which the information is accurate and consistent with the knowledge the reader and the disciplinary field believe to be “true.” Source credibility refers to the extent to which the source of the information (author or publisher) is credible. Context credibility refers to the extent to which the context in which the information is presented is credible. This context includes aspects such as currency, or when the text was written (Shanahan et al., 2011; Alexander & Tate, 1996) and text structure and presentation (i.e., text genre, such as blog, wiki, discussion forum, news article, journal article, informational website; url type, such as .edu, .org, or .com; layout; text features; grammar; structure, and spelling).

Evaluating information credibility. The present study views the process of evaluating the credibility of information as occurring in three ways. The first is by evaluating the credibility of

the knowledge claims provided using one's own understanding of the subject matter, or what Bromme, Kienhues, & Porsche (2010) call *first-hand evaluation*, and what is here called primary evaluation. The second is by evaluating the credibility of the source of that information, or what Bromme, Kienhues, & Porsche (2010) call *second-hand evaluation* and what is here called secondary evaluation. The third is by evaluating the credibility of the context of that information based on one's knowledge of how information should be structured and presented in a given discipline, what is here referred to as tertiary evaluation.

The present study views the process of fully evaluating the credibility of information as involving a triangulation of these three aspects of credibility. This means that fully evaluating the credibility of information requires a reader to consider and evaluate "all available evidence" (O'Byrne, 2012, p. 41) before determining the extent to which information is credible. Highly effective evaluation involves drawing on a variety of evaluation clues as evidence when judging the degree to which information is credible rather than relying on any one strategy alone (Coiro, Coscarelli, Maykel, & Forzani, 2015).

Since the present study assessed seventh graders, who were not expected to be expert online science evaluators, readers were only required to draw upon one piece of evidence in order to earn credit for the fourth evaluation score point (evaluating the overall credibility of information at a website). However, this evidence had to be either primary evidence (knowledge claim credibility) or secondary evidence (source credibility). Tertiary evidence (context credibility) alone was not enough to earn credit since it was viewed as providing clues as to the extent to which the primary and secondary evidence was credible.

The importance and difficulty of critical evaluation in online science. On the Internet, anyone may publish what he or she wishes. Compared to offline reading, there are far

fewer checks in place to vet this information before it reaches readers. Thus, effective online research relies on a reader's ability to evaluate the validity of the information he or she finds (Goldman et al., 2012; McVerry, 2013). For example, online publishing, unlike offline publishing, has few uniform standards regarding text type (Britt & Gabrys, 2001; Rouet, Ros, Goumi, Macedo-Rouet, & Dinet, 2011). As a result, information found online is more diverse, biased, and unreliable than that found offline (Flanagin & Metzger, 2010; Thoman & Jolls, 2005). The importance of critically evaluating information thus becomes compounded when reading on the Internet, and this is especially true for reading science texts.

The importance of critically evaluating texts is especially important in science. Studies of college students have found that critical evaluation is a particularly important skill for learning from Internet inquiry in science (Goldman et al., 2012; Wiley et al., 2009). Scientific information is often inconsistent and conflicting (Longino, 2002), and this problem is compounded on the Internet (Thomm & Bromme, 2016). While the Internet has resulted in a greater accessibility of science information, this information is often inconsistent (Stadtler & Bromme, 2014). As a result, the Internet has led to an increase in inaccurate and inconsistent information in science. This means that in an online environment, the ability to evaluate the credibility of science information is even more important than in an offline environment (Thomm & Bromme, 2016). Without the ability to evaluate the credibility of information, students may develop misconceptions about science (Wiley et al., 2009).

Despite the importance of critical evaluation in science, however, there is surprisingly little research investigating middle school students' abilities in critically evaluating online information, particularly compared to other important online research and comprehension skills. Much of what we do know about students' critical evaluation abilities has been learned from

research on older readers, including high school and college students (Wiley et al., 2009; Goldman et al., 2012), or younger readers, including upper elementary grade students (Macedo-Rouet, Braasch, Britt, & Rouet, 2013). A few studies that have focused on middle grade students have found that these students rarely question the accuracy of information (Barzilai & Zohar, 2012; Walraven, Brand-Gruwel, & Boshuizen, 2009; Zhang, 2013). Moreover, younger adolescents often overestimate their abilities to critically evaluate online information (Flanagin & Metzger, 2010; Miller & Bartlett, 2012). This may mean that students are less aware of the skills they need to obtain in order to read online effectively and that, in turn, they may be less likely to obtain these skills.

Several studies of secondary and college students have found that students are not especially skilled in this area (Goldman et al., 2012; Kiili, Laurinen, & Marttunen, 2008; Zhang & Duke, 2008). This is particularly true for science. For example, Halverson, Siegel & Freyermuth (2010) investigated how college students selected and evaluated websites when building understandings about stem-cell research. They found that students mostly used websites that were easily accessible and website evaluation criteria that were not focused on the content of the website but rather on superficial features. The researchers concluded that students did not engage in much evaluation of websites and, when they did, were not especially skilled at evaluating. Similarly, other research has found that even when students know about evaluation strategies, they may not use this knowledge in practice (Hogan & Vernhagen, 2012). Specifically, research on undergraduate students reading science information has found that students may be attuned to source information but that they may not use this source information when evaluating the extent to which the information they are reading is credible (Kobayashi, 2014; Strømsø, Bråten, Britt & Ferguson, 2013; Tabak, 2015).

A study of upper secondary students in Finland investigated different types of critical evaluators and found five different profiles of evaluators that included versatile evaluators, relevance-oriented evaluators, limited evaluators, disoriented readers, and uncritical evaluators (Kiili, Laurinen, & Marttunen, 2008). The researchers concluded that most of the students did not engage in critical evaluation very often. When students did evaluate, however, they most often evaluated the relevancy of texts. Despite the fact that readers did not critically evaluate the texts they read very often, the study found that most of the participants used texts written by a credible author or publisher.

Studies that have looked at upper elementary students' critical evaluation abilities have found that, as with older students, critical evaluation is an important but difficult skill for readers. A recent study that examined fourth and fifth graders' critical evaluation abilities (Macedo-Rouet, Braasch, Britt, & Rouet, 2013) with traditional, offline texts, found that the ability to critically evaluate informational texts is an important part of young readers' reading development. As with upper secondary and college-aged students, though, elementary students are not especially skilled in this area. Eastin, Yang, and Nathanson (2006), for instance, found that third, fourth, and fifth graders were not skilled at judging the reliability of online sources and often based their evaluations on superficial or irrelevant cues. Students in the study viewed websites with more graphics as more credible than websites with fewer graphics. Similarly, studies have found that younger adolescents, including middle school students, tend to believe that the greater the quantity of information, the greater the quality (Agosto, 2002; Wallace, Kupperman, Krajcik, & Soloway, 2000).

That some research supports the notion that students are not especially skilled at critical evaluation may provide support for the idea that critical evaluation is a more difficult skill than

location, synthesis, and communication. However, little research looks at critical evaluation compared to and in the context of other online reading skills. It may be that skills that are easier offline, such as locating information, may become more difficult online, especially given that evaluating may be much more involved in locating information online than it is offline.

Also, while some studies begin to provide a picture for us of younger and older children's abilities in the critical evaluation of online critical evaluation, additional studies are needed that focus particular attention on middle school students and on critical evaluation in the context of the entire online research and comprehension process. Moreover, none of these studies have investigated how performance differs by prior knowledge, gender, SES, or offline reading ability, or how critical evaluation performs compared to locating, synthesizing, and communicating. These are important areas of inquiry if we are to develop instruction that includes critical evaluation measures that can be used to design and implement targeted instruction for middle school students. The present study thus seeks to address these needs by investigating middle school students' abilities by four areas of individual difference in the critical evaluation of online information while engaging in a scientific research task online. It does so by first examining how online critical evaluation performs in relation to locating, synthesizing, and communicating during online reading and research to better situate critical evaluation as it functions in a real research context rather than situating it in isolation.

Comparing critical evaluation to location, synthesis, and communication. While theoretical constructions of online critical evaluation, as well as the assessment used in the present study, often treat this skill area as its own separate construct, little research provides information about the extent to which this is true. If critical evaluation is its own skill area, then we can define and measure student performance in this skill area compared to other, different

skill areas. If critical evaluation is not its own skill area, then we would need to define and measure it as part of a larger construct. Given that the present study proposes to define and measure critical evaluation as a construct separate from locating, synthesizing, and communicating, the present study first investigates this important issue.

It may be that critical evaluation does account for a relatively large degree of the variance in the other three skill areas. If this is the case, it may be that while critical evaluation is its own skill area it also is heavily intertwined with the other three skill areas. This would lend support to the notion that we should measure critical evaluation on its own scale but within the context of the other skills, as it is done in the assessment used here.

However, research on critical evaluation tends to evaluate this skill in isolation rather than viewing it in the context of the entire online research process, a process that includes other important skills such as locating, synthesizing, and communicating. Critical evaluation often is related to many different skills in online reading and research. A reader often uses critical evaluation skills in an iterative process that takes place throughout the research process (Graesser et al., 2008; McVerry, 2013; Zhang & Duke, 2007) and that is therefore intertwined with other online reading skills. In the process of locating usable sources, for instance, a student must evaluate the degree to which sources are relevant and reliable. For example, as a student reads through a list of search results in a search engine, she needs to determine which source(s) to click on, considering a source's potential relevancy and reliability. Once a student has clicked on a potential source, the locating and evaluating processes are further intertwined. As a student reads through the selected webpage and evaluating the source, she also is determining whether the source will be usable or whether she will need to go back and locate a different source. Similarly, if students have selected unreliable sources, their syntheses and communication of information

may be inaccurate, since they are using information from inaccurate texts. However, little research investigates students' critical evaluation capabilities within the context of other skills. Without doing so, it is difficult to measure accurately students' proficiency with this skill as it is used in real research or to understand how to conceptualize critical evaluation in the context of online research.

It is unclear how students might perform on critical evaluation when it is measured in the way in which it is typically used in real world research, in the context of other skills, and when it is compared to these other skills. On the one hand, critically evaluating may be easier than locating, synthesizing, and communicating given that it underpins these skills. Students must use evaluation in the process of engaging in these other skills. The online reading assessment used in the proposed study attempted to separate the skills as much as possible while still keeping the task authentic. Rather than having to locate the site that they evaluated, for example, students were provided with it.

On the other hand, critically evaluating may be more difficult than these other three skills. Evaluating is sometimes viewed as a higher-level skill that requires many other, lower-level skills such as remembering, understanding and analyzing (see Anderson et al., 2001, for example). Synthesizing may also be seen as a higher-level skill compared to locating and communicating. However, in the online assessment used in the present study, synthesizing is the skill that most closely resembles that used in offline reading. As such, it is likely that students have much more practice with the synthesis compared to the evaluate skill as they are measured in the ORCA, since students presumably have more experience with offline rather than online reading assessments. It is unclear then how students might perform in the evaluation of online texts compared to locating, synthesizing, and communicating information during online reading.

Scientific Literacy

In addition to learning about scientific literacy in its derived sense, or scientific content, students also need to learn scientific literacy skills in their fundamental sense (Norris & Philips, 2003) so that they can engage with scientific content and information in meaningful ways. Thus, as the importance of science and technology education has gained increasing attention, particularly with the United States federal government's focus on these areas, so too has scientific literacy in its fundamental sense, including the critical evaluation of information and information sources. [See, for example, the Federal Science, Technology, Engineering and Mathematics [STEM] Education 5-Year Strategic Plan (National Science and Technology Council, 2013)]. Merely teaching scientific concepts without also teaching the scientific literacy skills that students need is not likely to be effective (Cervetti, Pearson, Bravo, and Barber, 2005). Similarly, merely teaching generic literacy skills without also teaching the specific aspects of text and reading to which students need to be attuned in science also is not likely to be effective for helping students understand science well. Instead, students need to learn the science-specific literacy skills, or scientific literacy skills, they will need to deal with important scientific issues.

The growing field of disciplinary literacy for science has focused on the discipline-specific skills necessary for reading and understanding science (see, for example, Shanahan et al., 2011). While this research has mostly focused on offline scientific literacy, this research is useful for thinking about online scientific literacy. In the section below, research from the science field is integrated with research from the disciplinary literacy field to form a common picture of disciplinary literacy for science regarding science text and science readers.

Science texts.

Text types. Halliday & Martin (1993) described common genres of scientific text, including *experiment*, or explaining the purpose, methods, procedures, results, and conclusions for a given experiment; *report*, or organizing information through classification or description; and *explanation*, or describing how and why scientific processes occur. Another type of science genre is *argumentation* (see, for example, Brigandt, 2016). Explanation and argument are sometimes discussed as a single construct (see, for example, Krajcik & Sutherland, 2010). While the present study views explanation and argument as two separate but related genres, with some explanation involving argumentation and some argumentation involving explanation, the present study views all webpages used in the present study as involving argumentation. All websites in the present study included arguments and explanations that were related to two important life science topics common to seventh grade curriculums: the heart and the eyes.

Text features. Texts from different disciplines often contain different discourse and linguistic features a reader must interpret and use in ways specific to a given discipline (Shanahan et al., 2011). Scientific texts contain features specific to the field of science. Scientific texts tend to contain a high degree of discipline-specific technical vocabulary (Fang, 2005; Shanahan et al., 2011). These kinds of texts also tend to have high lexical density (Fang, 2005), meaning they contain a high number of content words in comparison to non-content words (Eggins, 1994). Additionally, scientific texts contain numerical and visual information, such as charts, tables, graphs, diagrams, symbols, images, and formulas, that are as important as prose (Lemke, 1998; Shanahan & Shanahan, 2008; Shanahan et al., 2011; Yore & Shymansky, 1991). In science texts, visual information can help to make the complex processes described in the text more understandable to readers (Kali & Linn, 2008). As well, scientific texts tend to contain

nominalizations, or nouns that have been transformed from verbs in order to name complex processes (Halliday & Martin, 1993; Unsworth, 1999). In the present study, the websites used contained science information that tended to contain many of these features. For example, in one of the webpage texts used for the Energy Drinks and Heart Health task (see Figure 2.5), the discipline-specific science terms “taurine” and “caffeine” are used.

Science readers. Disciplinary literacy perspectives consider not just the differences in texts among disciplinary fields but also the differences in readers. The skills and strategies that readers use and the ways in which readers approach text differs from field to field (Shanahan et al., 2011).

Reader skills and strategies. In addition to individual difference variables that may affect reading comprehension and evaluation in online science, much research indicates that readers’ skills and strategies impact their reading comprehension and are particular to a specific discipline. Many studies that illuminate reading strategy differences among different disciplines are expert-novice studies, which have played an important role in defining effective and high-quality performance (Newell & Simon, 1972). These kinds of studies have highlighted the differences between the ways in which novice readers interact with text compared to readers who are experts in their fields. These kinds of studies have shown that one key concern for scientists when interacting with text is critically evaluating the validity of the information (Shanahan et al., 2011). This is considered a key practice in the field of science (Halverson et al., 2010; NGSS Lead States, 2013).

Primary evaluation, argumentation, and corroboration. One important and necessary component that is at the core of what it means to engage in science through a fundamental sense of scientific literacy is *argumentation*, or the process of persuading others of the validity of one’s

claims using supporting information that can include a) logic or b) justified, scientific evidence (Duschl & Osborne, 2002; Jimenez-Aleixandre & Erduran, 2008; Driver, Newton & Osborne, 2000). Evaluating argument thus means evaluating the credibility of the information presented, by way of evaluating both the evidence and the logic used to support an argument, an essential aspect of scientific literacy (Britt, Richter, & Rouet, 2014). As such, critical evaluation is a key aspect of argumentation (Halverson, Siegel & Freyermuth, 2010). Given that anyone may publish what they wish online, critical evaluation is particularly important when reading in an online environment (Goldman et al., 2012).

The National Research Council's *Framework for K-12 Science Education* (National Research Council, 2012), the Common Core State Standards, or CCSS (CCSS, 2010), and the Next Generation Science Standards, or NGSS (NGSS Lead States, 2013), all include argumentation as an important component of scientific instruction. The Next Generation Science Standards (NGSS Lead States, 2013) are based upon three dimensions that include "disciplinary core ideas," or content; scientific "practices"; and "crosscutting concepts," or the ideas and practices that are common to multiple science domain areas (p. xv). In the NGSS Standards, argumentation is one scientific practice. These standards define scientific argumentation as "a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation" (p. 110) and point out that it is a central part of the nature of science.

Scientific explanation and argumentation texts, such as the texts used in the present study, require the reader to critically evaluate the validity of the information contained in arguments (Shanahan et al., 2011). This information contains arguments that a reader must evaluate in order to determine the extent to which the information in the explanation is credible (Britt,

Richter, & Rouet, 2014). In an online environment where anyone may publish what they wish, evaluating the credibility of information is especially important (Goldman et al., 2012).

Bromme, Kienhues, & Porsch (2010) describe two ways in which a reader might critically evaluate the validity of information and thus the author's argument. The first is through *first-hand evaluation*, or what is here referred to as primary evaluation, whereby a reader evaluates the author's argument based on his or her own understanding of the domain area. Readers compare what they are reading to their own prior knowledge (what we can think of as "text-to-prior knowledge") as well as to information found in other texts (what we can think of as "text-to-text") as they read and conduct research. Because the reader is attempting to corroborate what they are reading with background knowledge (either prior knowledge or knowledge gained from other texts), this is a process that is known in Disciplinary Literacy as *corroboration* (Wineburg, 1991; Shanahan et al., 2011). Research on science experts as they read show that scientists tend to be concerned with and aware of the ways in which new information fits into previous information and extends understanding in a given area.

Figure 2.5. “How Do Energy Drinks Affect Heart Pressure?”: A Science Webpage in the Energy Drinks and Heart Health Task

How Do Energy Drinks Affect Heart Pressure? | LIVESTRONG.COM

LIVESTRONG.COM Blog: The Fight Against Breast Cancer

LIVESTRONG.COM
DARE TO CHANGE YOUR LIFE

Google Custom Search

Fitnes Diet & Nutrition Tools Inspiration Calorie Tracker

Home > Diet & Nutrition > Dietary Supplements > Energy Drinks > How Do Energy Drinks Affect Heart Pressure?

How Do Energy Drinks Affect Heart Pressure?

Like Be the first of your friends to like this.

TEXT SIZE: A A | POST A COMMENT | PRINT | SEND TO FRIEND | Add to Favorites | Tweet 0

Ingredients

The majority of energy drinks share two key ingredients: taurine and caffeine. Taurine is a type of amino acid which fish, meats and other protein foods contain. Caffeine is a stimulant found in coffee, tea, soda and chocolate. Caffeine is sometimes utilized as a metabolism booster. According to the American Heart Association, an energy drink contains the same amount of caffeine as two cups of coffee, though some brands may contain more. These ingredients are aimed to keep you awake and alert, though they have the potential to adversely affect your [health](#).

Uses

Energy drinks are most popular among students and athletes who want an instant boost of energy. Although energy drinks are often used by athletes, they are different from sports drinks. Sports drinks contain water, salt and sugar, and are designed to replenish the electrolytes and energy your body loses during [exercise](#). However, sports drinks do not contain chemicals that directly increase your energy levels as energy drinks do.

Hartford Coupons www.Groupon.com/Hartford
1 ridiculously huge coupon a day. Like doing Hartford at 90% off!

Heart Rate

In 2007, Wayne State University in Michigan conducted a study on how energy drinks might affect [blood pressure](#) and the heart. Participants, who were in their 20s, drank two energy drinks a day for seven days straight. The participants did not consume caffeine for two days prior to the study. Heart rates were measured each day within two hours of consuming the energy drinks, while the participants were sitting down. The results showed that there was an average heart rate increase of 11 percent on the seventh day, an increase of up to seven beats per minute. Blood pressure also increased by over seven percent, which signified the added pressure to the heart.

YOU'LL BE AMAZED BY ALL YOU GET, STARTING AT \$70* A DAY.
CHECK IT OUT

Carnival
FUN FOR ALL. ALL FOR FUN.
Advertise Here advertisement

People Are Reading Related Topics

- The Effects of Energy Drinks on Blood Pressure
- Smart Shopping for Sugar-Free Energy Drinks
- Why Diet Energy Drinks Are Bad for You
- Ingredients in Monster Energy Drinks
- Muscle Building & Energy Drinks
- What Foods Affect Heart Rate?
- Health Effects of Energy Drinks
- Health Facts on Monster Energy Drinks
- What Are the Main Ingredients in Energy Drinks?
- Energy Supplements That Don't Increase Heart Rate
- What Are the Dangers of Energy Drinks and

This corroboration process of evaluating the author’s argument in relation to prior knowledge or to information from other texts requires a reader to evaluate the support for that argument. There are two ways in which an author might provide support for his or her argument: through internal logic, and/or through scientific evidence. In turn, a reader must evaluate the author’s argument by evaluating the internal logic of that argument or by evaluating the scientific

evidence the author uses to support that argument. In first-hand evaluation, or corroboration, the reader evaluates the internal logic of the ideas used to support the argument and/or the scientific evidence used to support the argument by comparing what they read to their own understanding of the subject matter from their prior knowledge and from other texts. In this way, the evaluation process is “first-hand,” or “primary” since the reader is evaluating the new information in relation to their own existing information. Logically, the more accurate the reader’s own understanding of the subject matter is, and the greater the reader’s own expertise in the subject area is (i.e. “first-hand” expertise), the better able to evaluate the credibility of the new information the reader will be. In this way, it makes sense that effective critical evaluation requires prior domain knowledge in the subject area of the information the reader is evaluating.

In the present study, students were asked to incorporate what they had learned from prior scientific inquiry into their new understanding through evaluation, synthesis, and communication. Additionally, students were asked to synthesize information they had learned from multiple texts throughout the task (texts from up to five different websites). Students were able to access some texts via links provided but had to access other texts on their own, using search querying.

Secondary evaluation and sourcing. The second way in which a reader might critically evaluate the validity of information, according to Bromme, Kienhues, & Porsch, 2010, is through *second-hand evaluation*, or what is here referred to as secondary evaluation. Secondary evaluation refers to the process of evaluating the source of the information rather than the information itself, as one does in primary evaluation. In the disciplinary literacy field, this process is known as *sourcing* (Wineburg, 1991; Shanahan et al., 2011). Shanahan et al., (2011), found that expert chemists were particularly attuned to the source of the information when evaluating quality, which provided clues as to the validity of the information. The chemists paid

particular attention to an author's reputation and the quality of the author's credentials.

Bazerman (1985) had a similar finding in regards to physicists.

The process of sourcing is "second-hand" because in this case, unlike in first-hand evaluation, the reader is relying on the expertise of another person rather than on his or her own expertise (i.e., "second-hand" expertise). Thus, if the reader trusts the expertise of the author or publisher (i.e. the source) of the information, then the reader uses the expertise of that author or publisher as a proxy for his or her own expertise. However, even this secondary evaluation might require some prior domain knowledge, as readers may need prior domain knowledge to determine which types of sources are credible and which are not.

Both first-hand evaluation and second-hand evaluation are important for readers of scientific text. Together, the information itself and the source of the information provide the reader with a more complete picture of the extent to which the information is reliable. The process of reading scientific explanations, in particular, may require an integration of both first-hand and second-hand evaluation. In explanatory or argumentation texts, the types of texts often found during a basic online research and comprehension task such as those used in the present study, scientific evidence used to support an argument often takes the form of secondary source evidence rather than of primary source evidence, as it would in experiment texts. When evaluating the evidence an author uses to support her argument, then, a reader might also need to evaluate the credibility of the source of this evidence. While a more experienced reader and expert scientist may navigate to, read, and evaluate the argumentation and the sourcing in a second text that is the primary source of the evidence, it is less likely that a more novice reader or scientist would do so. In either case, however, a reader would integrate both primary and secondary evaluation.

The present study focused particular attention on the skill area of evaluating the reliability of information, since that is a key area in the field of science. Evaluating the author (or publisher), or source of the information, was used as one of the process score points for evaluating the reliability of information at the site, as well as an acceptable scoring criteria for the product score point, or evaluating the overall reliability of the information on a webpage.

Evaluating online science information. Evaluating scientific information is especially important given that so much of the science information people engage with is found online (Horrigan, 2006). Students and adults often use online information when conducting research in science. In a 2001 study, for example, 94 percent of students with Internet access reported that they used the Internet for school-related research (Lenhart, Simon, & Graziano, 2001).

However, information found online may not be reliable given that anyone may publish anything they wish online. A recent study, for example, found that even seemingly trustworthy sites are likely to contain inaccurate scientific information (Chung, Oden, Joyner, Sims, & Moon, 2012).

Unfortunately, most current assessments do not specifically provide a way to measure students' abilities in critically evaluating online information in science. Before teaching critical evaluation of online science information, we need to better understand students' current skills in this area to provide direction for future curriculum, instruction, and research. Additionally, understanding how important individual difference variables affect students' learning is a necessary step in designing instruction to meet the needs of different students.

Interestingly, the field of disciplinary literacy, including the field of scientific literacy, largely has ignored online texts and informational spaces, despite the fact that the Internet has become a central source of information (Leu et al., 2013). While some have begun to tie these fields together (see, for example, the work of Goldman et al., 2012 and Wiley et al., 2009, which

touches upon scientific literacy in online environments, and Manderino, 2012, which focuses on the field of history in online spaces), there is little work in this area. This is problematic given the increasing importance and use of online texts in science (Horrigan, 2006). The present study thus seeks to extend the work of the scientific literacy field into the online information space to include online texts in science and the practice of evaluating online information. Evaluating online information is a central aspect of scientific literacy that may have specific consequences for individual difference variables that are different from those consequences that result from engaging in offline environments.

Individual Difference Variables in Reading and Science

A large body of work investigates various individual difference variables in learning and achievement, including differences related to prior domain knowledge, gender, SES, and more (see, for example, Jonassen & Grabowski, 2012). This work has shown us that individual differences can have a large and impactful effect on students' learning outcomes (Jonassen & Grabowski, 2012). This research includes outcomes related to both offline and online reading (Afflerbach, 2015; Leu, Kiili, & Forzani, 2015) as well as to science (Katz et al., 2006).

Prior domain knowledge. When referring to prior knowledge in the present study, I specifically refer to prior domain knowledge, or the deeper knowledge that results from a student being exposed to an informational domain multiple times across a period of time (Alexander, 2003). In the area of reading specifically, the prior domain knowledge that a reader brings to a text plays an important role in his or her comprehension of that text (e.g., Anderson & Pearson, 1984; Bransford & Johnson, 1972; Kintsch, 1998; McNamara & Kintsch, 1996; Means & Voss, 1985; Pearson, Hansen, & Gordon, 1979; Voss & Silfies, 1996). Information stated in a text often is insufficient for a reader's understanding, requiring the contribution of a reader's domain

knowledge (Kintsch, 1998; McNamara & Kintsch, 1996; Voss & Silfies, 1996). Thus, readers with higher degrees of prior knowledge tend to be better at comprehending texts than readers with lower degrees of prior knowledge (Baldwin, Peleg-Bruckner, & McClintock, 1985).

Prior knowledge in offline informational reading. Prior knowledge is particularly important for expository/informational text comprehension (Afflerbach, 1986; Chi, Feltovich, & Glaser, 1981). When reading informational text, readers use prior knowledge to help them determine importance (Afflerbach, 1986), draw inferences (Graesser, Singer, & Trabasso, 1984), and construct meaning (Anderson & Pearson, 1984). Several studies have shown that when reading science texts, specifically, the degree of prior knowledge a reader brings to a text significantly impacts comprehension, with greater prior knowledge leading to greater comprehension (Chi, 1978; Chi, Feltovich, & Glaser, 1981).

Much prior research suggests that prior topic knowledge, in particular, plays an important role in scientific text comprehension (Bonner & Holliday, 2006; Cromley, Snyder-Hogan, & Dubas, 2010; Gilabert et al., 2005; Kendeou & van den Broek, 2007; Miller, Cohen, & Wingfield, 2006; Ozuru, Best, Bell, Witherspoon, & McNamara, 2007; Ozuru, Dempsey, & McNamara, 2009; Surber & Schroeder, 2007; Taboada & Guthrie, 2006; van den Broek & Kendeou, 2008). For example, Ozuru, Dempsey, and McNamara (2009) found that together, disciplinary knowledge in biology and topic-specific prior knowledge accounted for about 20% of the variance in students' scores on text-based comprehension questions. Cromley, Snyder-Hogan, & Dubas (2010) found that even after controlling for strategy use, inferencing, vocabulary, and word reading, prior topic knowledge contributed significantly to students' comprehension of science text.

However, this research on prior domain knowledge has examined the role of prior domain knowledge in offline rather than in online reading. It is thus unclear whether prior domain knowledge might have the same effect in online reading, and, more specifically, in online critical evaluation. Some studies of the role of prior knowledge in online reading are beginning to emerge that inform the present study.

Prior knowledge in online informational reading. One study that examined the effects of prior domain knowledge in online reading found that even those students with limited prior domain knowledge were able to locate relevant and reliable information (Willoughby, Anderson, Wood, Mueller, & Ross (2009). Similarly, another study found that prior knowledge scores did not significantly impact online reading scores (Leu et al., 2014).

Another study found that prior domain knowledge contributed a significant amount to the variance in online reading for poorer online readers but not for average and highly skilled online readers (Coiro, 2011). The researcher theorized that this may have been because average and highly skilled online readers had the skills to obtain the background information they needed by locating the information online whereas the poorer online readers lacked the skills to be able to do so.

The present study investigated the extent to which individual differences in prior domain knowledge in two different science topic areas impacts outcomes for students in online critical evaluation specifically. It may be that prior knowledge has a greater effect on the component skill of critical evaluation specifically compared to online reading as a whole. Readers may need a solid understanding of prior disciplinary and domain knowledge in order to effectively evaluate the reliability of a source (Stadtler, Scharrer, Macedo-Rouet, Rouet, & Bromme, 2016). This is because, in order to score a point, students needed to accurately evaluate the quality of the

writer's argument, which involves an understanding of the scientific concepts behind that argument. Readers also may need additional kinds of prior knowledge when critically evaluating sources than just domain knowledge, however. In addition to evaluating an author's argument, the reader might use background knowledge about the author or publisher to help determine the degree to which the source is reliable. This might require knowledge about certain types of degrees, schools, experiences, and jobs, and how that information relates to the author's potential expertise on a topic.

Some studies have shown that prior knowledge has a significant effect on students' online reading comprehension, particularly in the area of science. Some research suggests that readers with higher degrees of prior knowledge may be more proficient at integrating information across prose and graphic text (such as supporting diagrams), when reading science information. This is an important skill for science readers (Yore & Shymansky, 1991). In a recent eye-tracking study, researchers tracked readers' eye movements while they read online science text. The researchers found that students with higher degrees of prior knowledge engaged in greater degrees of inter-scanning between the prose text and the supporting diagrams than did the students with lower degrees of prior knowledge (Ho, Tsai, Wang, & Tsai, 2014).

Given that prior domain knowledge plays an important role in offline reading and that it may play a similar but more complex role in online reading, it is unclear what effect it might have on online critical evaluation specifically. This is important to know, since teachers may need to help students evaluate online texts specifically within the context of different content areas. Additionally, teachers may need to help students build prior knowledge about how different types of experiences, degrees, jobs, affiliations, and more might make an author or publisher more or less reliable, particularly in a given domain area. Therefore, in the present

study, prior domain knowledge is treated as one of several individual difference variables explored in relation to online reading.

Gender. A long line of research indicates that gender may play a role in academic achievement. Many studies have shown differences between males and females in general academic achievement, with females earning higher grades than males and finishing high school at a higher rate (Jacob, 2002). This trend is born out in both science and reading achievement as well, but in different ways.

Gender and science. There is much consensus that women are significantly underrepresented in the sciences (Brotman & Moore, 2008; Miller et al., 2006; National Academy of Sciences, 2005; National Science Board, 2003; Stake, 2006), with the majority of STEM jobs in the United States occupied by men (National Science Foundation, 2015; Riegle-Crumb & King, 2010). In 2012, women earned only about 40% of the doctorates in the United States in science and engineering (National Science Foundation, 2015). And, in 2013, women were employed in only about 32% of all science and engineering occupations (National Science Foundation, 2015).

Some suggest this may be due to gender differences in achievement, as seen on both standardized and classroom assessment tests (Gilbert & Calver, 2003; Katz et al., 2006; Thiers, 2006). In the 2011 TIMSS, for example, there was a significant difference between the performance of fourth grade girls and boys in science, with boys scoring, on average, ten points higher than girls. This gap persisted into eighth grade, with boys scoring 11 points higher than girls (Martin, Mullis, Foy & Stanco, 2012).

Some research, however, suggests that performance differences in science between men and women may be disappearing (Ma & Wilkins, 2002; van Arensbergen, van der Weijden, van

den Besselaar, 2011). This may be especially true for particular areas of science. For example, in 2014, women earned only 28.6% of the doctoral degrees in Physical sciences, though they earned 56% of the doctoral degrees in the Life sciences (National Science Foundation, 2014). Despite these earned degrees, however, women are still underrepresented in life science occupations. In 2013, women occupied only about 39% of life science occupations. This discrepancy between earned life science degrees and life science occupations for women compared to men may be due to the fact that as the achievement gap between men and women in science decreases, some men are replaced by women in science occupations, evening out the male/female ratio in the field. An alternative possibility is that while women and men earn a similar amount of life science degrees, employers are still hiring more men than women. It is important to note that in the present study, all four research tasks related to life science.

Gender and reading. We see a similar pattern regarding the effects of gender on reading, but with the gender gap reversed. Research suggests that, compared to girls, boys struggle with literacy (Farris, Werderich, Nelson & Fuhler, 2009; Kush & Watkins, 1996). In both national and international reading assessments, girls repeatedly outperform boys (Logan & Johnston, 2010; Moss, 2000). Chiu & Chow (2010), for example, found that girls performed significantly better than boys in reading test scores from the 2000 PISA, or the Programme for International Student Assessment, in most of the 41 countries they investigated. Similarly, findings from the 2011 PIRLS (Progress in International Literacy Study) assessment showed that, on average, girls performed 16 points higher than boys (Mullis, Martin, Foy, & Drucker, 2011). This gap was smaller for informational reading (girls had a 12 point advantage) than for literary reading (girls had a 20 point advantage) but still quite large.

However, some studies show that males have more positive relationships with technology and online reading than do females. For example, in a study of Chinese college students' online reading behaviors, Liu & Huang (2008) found that male and female students' preferences for reading digital texts were different, with girls preferring to read in paper formats and boys obtaining a greater degree of satisfaction with online reading than females. It is possible that this pattern may carry over into online reading and, specifically, into the critical evaluation of online information. At the same time, however, some studies have shown that there are no differences between boys and girls in their attitudes towards the Internet (Kim, Lehto, & Morrison, 2007; Koohang & Durante, 2003). Hargittai & Shafer (2006) found that in basic online research tasks related to everyday activities such as buying a car or conducting a job search, there was no significant difference between men's and women's abilities after controlling for SES and computer and Internet-use experiences. However, experience with the Internet was an important predictor. Therefore, if boys have a greater preference for digital text than do girls, they may engage in Internet research more often than girls, leading to higher degrees of performance.

It is thus unclear whether girls or boys might tend to perform better on measures of online research and comprehension. It is possible that boys' preferences for online texts over paper texts might serve as a moderating variable to lessen the gap between male and female reading comprehension performance.

Given that there is some indication that females may perform more poorly than males in science, though, we may see little difference between males and females in online reading in science, with males' science advantage and females' reading advantage in effect "canceling each other out." We may also see this pattern given that more recent research indicates that the gender

gap in science may be disappearing, and given that boys may have a “technology advantage” in reading over girls.

Socioeconomic status. As with gender, much research points to the effects of SES on academic performance, with students from higher income families significantly and consistently outperforming students from lower income families on multiple academic measures (Coleman et al., 1966; Sirin, 2005). SES further complicates the picture of struggling readers, particularly in the area of online science reading.

Research suggests that achievement in science is strongly and positively correlated with parent SES (Fuller & Clarke, 1994; Lees, 1994; Young & Fraser, 1993), with students from higher-income families outperforming those from lower income families in science (Yang, 2003). Ma & Wilkins (2002) found that students from high SES families actually made progress in science at a significantly faster rate than did students from low SES families.

This pattern persists not just with science but with offline reading as well. On the 2011 and 2013 NAEP assessments, students who were eligible for the National School Lunch Program performed two thirds of a standard deviation in scaled reading scores behind those who were not eligible for this program (NCES, 2011b, 2013). Moreover, this gap between wealthier and poorer students in offline reading achievement is actually increasing (Bailey & Dynarski, 2011; Reardon, 2011, 2013).

That SES has an effect on reading achievement is especially apparent for early reading outcomes (Snow et al., 1998). However, less is understood about the effect of SES on reading achievement as students get older and further develop their reading skills (Kieffer, 2012). Kieffer (2012), for example, found that children from low-SES families had faster reading growth before third grade but slower reading growth between third and eighth grade compared to their high-

SES peers and suggested that schooling may account for these differences earlier but not later. Students from high-SES families may benefit from greater access to resources that help set them up for success in school compared to their lower-SES peers (Bradley & Corwyn, 2002).

In addition to studies of family-level SES, studies of school-level SES also have found that school-level SES negatively impacts achievement (Caldas & Bankston, 1997). For example, a recent study found a negative correlation (-.37) between students eligible for free and reduced price lunch and reading comprehension, indicating that school-level SES had important effects on reading comprehension (Hart, Johnson, Schatschneider, & Taylor, 2013).

Similarly, another study by Leu et al. (2014) that looked specifically at online reading comprehension in the context of Internet research found that there was a significant difference between students from a high- and a low-SES school district for online reading performance. Students from the low-SES district scored significantly lower on a measure of online reading comprehension than did students from the high-SES district. The researchers also found that students from the low-SES school district had significantly less access to computers at home and were significantly more likely to never have been required to use the Internet at school compared to students from the high-SES school district.

Given the results of this study, it would make sense that SES would have a significant effect on online critical evaluation since online critical evaluation is one aspect of online reading and is an important predictor of it (Goldman et al., 2012; McVerry, 2013). The study by Leu et al. (2014), however, only used two school districts and did not focus on critical evaluation specifically. It is possible that because critical evaluation is such a difficult skill, there is little difference between students from higher and lower income schools. The current study therefore

seeks to investigate this difference with a much larger sample size and with a focus on critical evaluation, one of the most important of the online reading and research skills.

Offline reading ability. In addition to those skills and strategies used in offline contexts, reading in online contexts may require additional skills and strategies that are similar to but more complex than reading in offline contexts (Coiro & Dobler, 2007). Zhang & Duke (2008) found that readers reading for several different purposes used both traditional and new reading strategies when reading on the Internet. Similarly, Afflerbach & Cho (2008) identified a group of reading strategies particular to online contexts, which they called “realizing and constructing potential texts to read” (p. 212). This group includes selecting and following the most useful reading path. To obtain quantitative evidence to support Afflerbach & Cho’s (2008) recommendation that this category of strategies be included in Pressly & Afflerbach’s (1995) set of reading strategies, Coiro (2011) investigated the extent to which offline reading scores contributed to students’ scores on an online reading measure. She found that offline reading comprehension skills made significant contributions to students’ online reading comprehension scores, thus complicating the notion that offline and online reading are not isomorphic, an idea put forth by Leu et al. (2007). Leu et al. (2014) had a similar finding, with offline reading scores on a state standardized test contributing significantly to online reading comprehension scores.

The present study may provide further evidence for this idea if offline reading is found to contribute to students’ critical evaluation abilities. However, critical evaluation is only one aspect of online reading comprehension. Offline reading tasks often do not require students to evaluate the reliability of their sources but rather assume that students are using sources that are reliable to begin with, since published sources typically require at least one additional level of accountability regarding reliability (the publisher) than do Internet sources. Given this, we

would expect to find that offline reading does not contribute significantly to online reading. It seems more likely, however, that it would contribute somewhat, given that critical evaluation is an important component of online reading and given that online and offline reading likely share some, if not many, of the same strategies. Therefore, in the present study, offline reading was treated as an individual difference variable that might contribute to students' ability to critically evaluate online information.

Much offline reading research has found that readers with strong comprehension abilities better understand what they read because they are better able to make mental representations of the words they read (Perfetti & Hart, 2002), are better at making inferences (Cain, Oakhill, Barnes & Bryant, 2001; Long, Oppy, & Seely, 1994; Oakhill, 1984), use more reading strategies (Bereiter & Bird, 1985; Goldman & Saul, 1990; Long et al., 1994), and have greater motivation (Lau & Chan, 2003) than readers with less skill in comprehending information. These characteristics of good comprehenders may well apply to online reading as well, since online reading, like offline reading, requires readers to make mental representations, draw inferences, and use reading strategies. Motivation is likely to play a role in online reading similar to the one it plays in offline reading, since readers who are motivated to read will likely be more engaged in the text.

With science text specifically, offline reading ability has been found to influence students' comprehension. A study by O'Reilly and McNamara (2007) found that, in a between-subjects study, comprehension skill benefited both low- and high-knowledge readers when reading biology text. Ozuro et al. (2008) had similar findings but using a within-subjects design. In their study, students' level of reading skill significantly impacted performance on comprehension questions after reading a biology text. Given the importance of offline reading

ability to students' comprehension of both offline and online text, especially in science, we might expect to find a similar contribution in the present study. However, the present study looked specifically at critical evaluation, and so it was expected that the effects of offline reading comprehension on this one aspect of online reading comprehension might differ. In fact, the skills required to evaluate the credibility of online information in the present study did not necessarily require the same use of mental representations, inferencing, motivation, or even reading strategy as might be required when the purpose for reading a text is to obtain information rather than evaluate its credibility.

Integrating Perspectives and Research: A Framework for Discipline-specific Online Research and Comprehension in Science

In the following section, I integrate the relevant theoretical perspectives and research into a working framework for discipline-specific online research and comprehension that framed this study (see Figure 2.6). Like the RAND Reading Study Group model of offline reading comprehension, the present study views the discipline-specific process of online research and comprehension in science as an interaction of texts, readers, activity, and contexts that include the greater contexts specific to the science community and the Internet (see Figure 2.6). However, this model is further developed from the perspectives of online research and comprehension (Leu et al., 2013) and a discipline-specific (Shanahan, 2008) online informational context. In this model, the reader's goal is to investigate and respond to a research question, and the reader uses the steps of 1) Constructing a text set, 2) Making-meaning from the selected texts, and 3) Drawing conclusions from the selected text and presenting them to others to accomplish this goal. Throughout these steps, the reader uses self-regulation to monitor comprehension and progress towards his or her goal while he or she engages in four core general online reading

strategies that include locating, evaluating, synthesizing, and communicating. These strategies are discipline-specific in the ways in which they interact with text, reader, and context. Readers, for example, might employ these strategies differently in different disciplines.

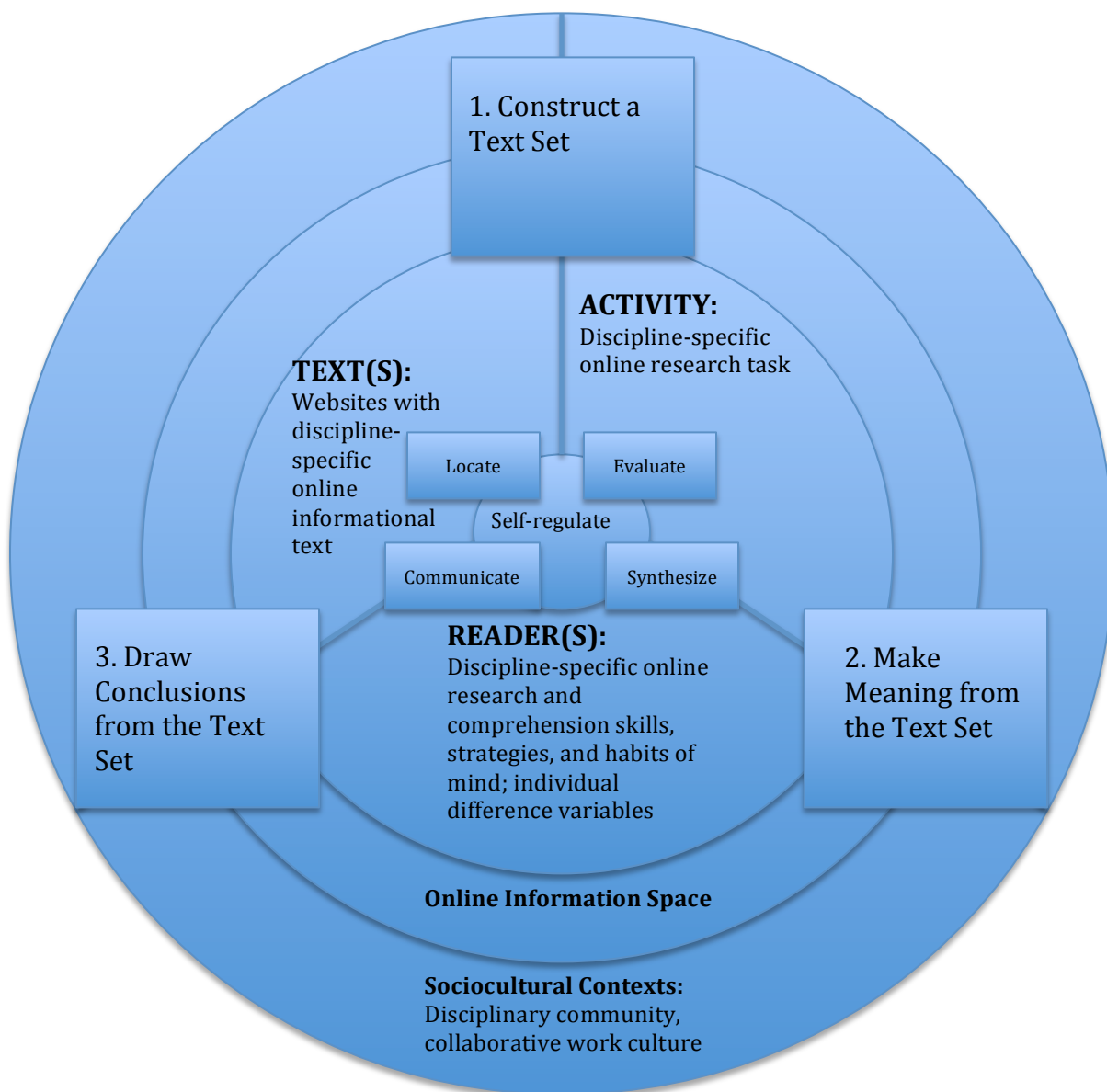
While the Internet is an important context of online critical evaluation in science (Horrigan, 2006; Thomm & Bromme, 2016), the present study views the Internet as an information space that influences the text, reader, and activity, resulting in new skills, strategies, and dispositions required for comprehension (see Figure 2.6). In this model, the text, reader, activity, and context all influence one another in a recursive process that evolves as the technology of the Internet evolves, resulting in the sense of new literacies that Leu (2000; Leu et al., 2013) refers to as *deictic*. That is, the meaning of literacy continuously changes as new technologies on the Internet change and influence literacy practices.

In the present model, therefore, as the information space has changed from offline to online, and even as it continues to change within an online context, science texts change, as do readers' skills, strategies, and dispositions. The present study assumes that through this process, not only are text, reader, and context discipline-specific in some ways, but they are also Internet-specific in some ways. In other words, the texts, reader skills, strategies, and dispositions, and contexts become, in some ways, specific to both science and the Internet – online research and comprehension in science.

As such, the critical evaluation of online information in science has become, in many ways, specialized to the ways in which it functions in relation to online science that is different, in some ways, to offline science and offline critical evaluation of scientific information. In the present study, therefore, I consider the reading and evaluation process from the perspective of the specific demands of scientific literacy in an online environment. In each of the following

sections relating to text, reader, and activity and context, I describe and provide examples for some of the ways in which the demands of scientific literacy in an online environment are used in the assessment in the present study, particularly in relation to online critical evaluation in science.

Figure 2.6. The Three Steps and Five Core Strategies of Online Research and Comprehension Within a Given Discipline: A Working Model for Disciplinary Online Research and Comprehension



Online Science Text

In the field of science, scientific texts are important in their own right, as scientists are always working within the larger conversation of past scientific inquiry when engaging in new scientific inquiry (Pearson et al., 2010; Saul, 2004). In the present study, the texts used were science webpages.

Online texts contain features that are specific to their online environment (Coiro & Dobler, 2007). Online science texts are thus a highly specialized kind of text, containing features unique to both their science and online natures. In the present study, the science webpages used contained these features of scientific text but in ways that were specific to their online nature. Online texts contain certain features that are not found offline, such as hyperlinked text and multimedia features (Coiro & Dobler, 2007). For example, the texts contained multimedia charts and diagrams, some of which were interactive. The texts also contained links to additional information, such as author biography pages or additional sources. Thus the texts used in the present study contained features specific to both their scientific and online nature in ways that were “online science-specific.”

Rather than merely containing technical vocabulary specific to science, as offline science texts do, some of these texts contained multimedia technical vocabulary, or “clickable” technical terms specific to science that provided a definition. For example, the critical evaluation webpage for the Video Game and Eye Health task contained the clickable term “computer vision syndrome” (see Figure 2.8). Clicking on this term took the reader to another webpage that more fully described this condition. Similarly, some of the texts contained charts or diagrams that were clickable. For example, the critical evaluation page for the Energy Drinks and Heart Health task contained a clickable chart (see Figure 2.7) that allowed the student to view the sourcing

information for the chart. Navigating to a secondary page with the chart allowed the reader to evaluate the chart, or one piece of primary source evidence the author used to make his argument. This piece of evidence, as well as its source, were important tools a student needed to use in order to evaluate the reliability of the information at the site. Finally, many of the science texts contained clickable corroborating information to aide students in their evaluation decisions. The evaluation page for the Energy Drinks task, for example, contained a link to a related story (see “For more, listen to this related story...” in Figure 2.7 or “Suggested reading...” in Figure 2.8). In this way, the online science text features are intimately related to the reader skills required.

Online Science Readers: Strategies and Individual Difference Variables

In the framework of online reading in science used in the present study, individual difference variables are viewed as having important influences on reading comprehension. These individual difference variables have consequences for comprehension that are particular to the discipline of science as well as to the online nature of the reading tasks. For example, some research indicates that the individual difference variable of prior knowledge has consequences for online reading, including critical evaluation, that may differ from those of offline reading (Coiro, 2011; McVerry, 2012).

Similarly, gender also impacts comprehension of offline science text (Yang & Tsai, 2014) and may have further unique effects in an online environment compared to an offline one. Thus, gender may play an important and unique role in comprehending and evaluating online texts in science.

Figure 2.7. The Energy Drinks and Heart Health Webpage Used to Assess Critical Evaluation Skills



Skills



Online Science Activities and Context

The framework for the present study also considers the reading context as an important factor. In scientific literacy, many activities and contexts might be considered relevant to reading. These include contexts such as the purpose of a given genre, the greater scientific community, and the particular domain, or scientific area, of the text, all of which were relevant in the present study.

Another important context in science reading is the information space. The Internet has become an especially important context for reading and doing science. The Internet is a context that requires new skills and strategies (Afflerbach & Cho, 2009; Coiro & Dobler, 2007). STEM programs aimed at improving students' science abilities specifically have called for improving students' abilities with the technologies they will need for scientific understanding (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011). These abilities include reading and conducting research in online environments, as reading and evaluating scientific information is important to the field of science (NGSS Lead States, 2013), and online texts have become a primary source of information about science (Horrigan, 2006). In science education in particular, instruction often involves reading science-related issues on the Internet and making judgments about the credibility of the information (Tsai, Hsu, & Tsai, 2012). Because of the importance of knowing how to evaluate online information to the field of science, the present study sought to investigate students' critical evaluation abilities in science specifically in an online context, using online texts and the scientific context of the research process. Thus the model of critical evaluation of online information in science described in this section helped to frame this study.

While prior research in offline reading and science provides an idea of what we might expect to find in the present study regarding individual variables, including prior knowledge, gender, SES, and offline reading ability, in online reading, we do not know how these individual variables will, in reality, affect performance in online critical evaluation within an online research task in science. This is important information to know so that we can develop instruction to fit the specific needs of students with different economic backgrounds, genders, and offline reading abilities.

Over thirty years ago, Artley (1981) pointed out that, rather than focusing on what little a diverse group of readers might have in common and aiming instruction at these needs, reading instruction ought to address the needs of individuals. Today, this idea is echoed by Afflerbach in his introduction to the *Handbook of Individual Differences in Reading* (2015).

Despite a growing body of research pointing to the effects of various types of individual differences in reading, much research on reading comprehension has focused on a homogenous group of proficient readers rather than examining specific issues particular to different types of readers (see, for example, Dole, Duffy, Roehler, & Pearson, 1991 and Duke & Pearson, 2002). Moreover, even fewer studies have examined individual differences related to online research and comprehension, and, particularly, to the critical evaluation of online information, especially from a disciplinary literacy perspective or in science, specifically. The studies that have examined individual differences in online research and comprehension have found that these differences have important consequences for student learning outcomes and for the way we teach students. It is important then to better understand the relationship of offline reading differences to online reading.

As such, we need to consider how to design instructional interventions aimed at preparing students effectively for science and scientific literacy, including the critical evaluation of online information, while providing all students the opportunity to achieve in this important area. Not surprisingly, the Common Core State Standards have included critical evaluation skills as essential skills for students to acquire (CCSS, 2010). The Common Core standards call upon readers to assess the credibility and accuracy of information gathered from multiple sources, including digital ones, for the purpose of presenting a synthesized summary of what a student has learned (CCSS, 2010). To meet this challenge, instruction in this area must help students think critically about online information in effective ways.

Before we can do this, however, we need to better understand younger, middle school students' online critical evaluation abilities, as well as the effect of individual differences as they relate to online source evaluation in science. Understanding students' current capabilities in critical evaluation is essential for helping teachers plan instruction that is targeted to fit individual students' unique and needs. Specifically, we need to better understand how well learners critically evaluate information compared to other online reading and research skills, how well they critically evaluate online information in different component skill areas, and how individual differences might affect students' ability in this important skill are. Better understanding these areas will provide direction as we develop curriculum and instruction aimed at building online critical evaluation skills in the area of science that is targeted to the specific needs of different types of learners.

Therefore, the present study seeks to initiate a better understanding of the middle grade students' online critical evaluation capabilities within the area of science, as well as the effects of individual difference variables on these capabilities. The study does so by building directly on

emerging findings around critical evaluation, the unique aspects of online informational text in science, and four important individual difference variables in science and reading: prior knowledge, gender, socioeconomic status, and offline reading ability. The purpose of the proposed study therefore is to investigate how well seventh grade students critically evaluated online information in science, especially compared to three other online reading skills, and the effects of four individual difference variables on that performance. Specifically, this study will investigate the following two research questions:

- 1) What is the nature of students' ability to critically evaluate online information in relation to three other skill areas required during online reading in science?
- 2) During online reading in science, to what extent do prior knowledge, gender, SES, and offline reading ability contribute to students' ability to critically evaluate the credibility of online source information?

The findings from this study will be important in the quest to teach young students the online scientific literacy skills they need to be successful in the field of science as well as in their everyday lives. This is a critical area right now but one in which we have little understanding. Findings from this study will provide information about students' current performance in online critical evaluation in science as well as information about the extent to which prior knowledge, gender, offline reading, and school average SES affect students' abilities in this area. These findings will thus provide important initial information to educators and researchers that can be used in both research and practice about how best to address the needs of all students when helping students' develop these valuable skills.

Chapter Summary

In this review of theoretical perspectives and research, literature was reviewed that was related to several areas relevant to online evaluation of information in science. These areas included research around the following areas: offline and online reading, including critical evaluation of the credibility of information; disciplinary literacy and, specifically, scientific literacy; and individual difference variables, including prior knowledge, gender, offline reading ability, and SES.

The review sought to determine prior effects of critical evaluation on online and offline reading as well as the effects of all four of these individual difference variables on students' ability to critically evaluate online information. In so doing, the review sought to investigate the ways in which these fields intersected in ways that were relevant for moving these fields forward. Specifically, the review was interested in examining the ways in which prior research in these fields could be intersected to provide framing for the present study, with the goal of considering the ways in which problems that education faces in science and literacy today could be addressed.

CHAPTER III

METHODS AND PROCEDURES

Participants

Participants included seventh grade students who participated in Year 4 of a five-year study examining students' online research and comprehension ability. This included students who took one of the Online Research and Comprehension Assessments II, as well as an offline reading measure, as part of The ORCA Project (Leu, Kulikowich, Sedransk, & Coiro, 2009-2014).

As such, participants included a total of 1,434 students from two different states in the Northeast, with 767 students from State A and 667 students from State B. This included 736 girls and 698 boys. This also included 17 school districts in State A and 23 school districts in State B, with one school in each district. See Table 3.1 for additional demographic data.

State A was a state that did not include any kind of laptop or computer program; State B was a state with a one-to-one laptop program. These two states were selected to provide a sample that was more representative of the United States as a whole, since some states have laptop programs and some do not. In the present study, student scores from both states were combined after prior analyses revealed that there was no significant difference in student scores between states (Forzani, Maykel, Flake, & Leu, in preparation).

Districts and schools were selected based on a sampling plan that stratified districts by SES, geographic area (urban, suburban, rural), and mean reading comprehension score on standardized state tests. For each school that was selected according to this plan, principals were instructed to select two English Language Arts teachers whose heterogeneous classes represented the larger student population of the school. Each English Language Arts teacher was then asked

to select two of his/her classes to participate in the study. Again, the teacher was instructed to select two heterogeneous classes that represented the larger school population. All students in each class were invited to participate in the study. However, only those who returned a parental permission form and who also signed a student assent form were allowed to participate. This included approximately 20 students per class.

Table 3.1

Demographic Data for State A and State B

| | State A | State B |
|---|---|--|
| Two-year average median family income in 2012-2013* | \$66,481 | \$49,997 |
| Population in 2014** | 3,596,677 | 1,330,089 |
| Ethnic Makeup** | 81.6% white, 11.3% Black or African American, .5% American Indian and Alaskan Native, 4.3% Asian, .1% Native Hawaiian or Other Pacific Islander, 14.7% Hispanic or Latino, and 2.1% two or more races | 95.2% white, 1.4% Black or African American, .7% American Indian and Native Alaskan, 1.1% Asian, <.5% Native Hawaiian or Other Pacific Islander, 1.4% Hispanic or Latino, and 1.6% two or more races |
| Mean Scaled Reading Score for NAEP 2013*** | 274 | 269 |

Notes. * U.S. Department of Commerce, 2015b; ** U.S. Department of Commerce, 2015a; *** U.S. Department of Education, 2013

Instrumentation

Online Research and Comprehension Assessments-II (ORCA-IIs)

Data from the online research and comprehension assessment used in this study comes from the Online Research and Comprehension Assessment II (ORCA-II). The ORCA-II is an

assessment that was designed as part of a five-year federal grant to assess students' ability to read and conduct research online in science (Leu et al., 2009-2014).

The ORCA-II was designed for use during Year 4, or the validation year, of The ORCA Project grant (Leu et al., 2009-2014). Prior to creation of the ORCA-II, two rounds of testing were conducted: First, pre-pilot testing in two school districts in one state was conducted with a pre-pilot assessment. Second, pilot testing in 41 districts in two states with a revised set of assessments, or ORCA-Is, were conducted. The ORCA-IIs were a further revised set of assessments based off of the two earlier versions. You can view a video that provides an overview of the ORCA-IIs here: <https://www.youtube.com/watch?v=aXxrR2wBR5Y>

In the ORCA-II, students engaged in an online research task in which they worked with two avatar students and a fictitious school board president to research a practical life science problem and provide a brief response via either email or wiki to the school board president. The avatars were used to resemble actual online research, which often occurs in a collaborative environment (Engeström & Sannino, 2010; Leu et al., 2013). Given that reading traditionally has been assessed in an individual, rather than a collaborative, context, using an avatar may alter the outcomes of the reading assessment compared to that of traditional reading assessments.

Students worked within a social network environment as the avatars provided prompts and students typed their answers into a comment box. Students conducted research using a closed Internet system and a search engine called "Gloogle." In two of the assessments, students were given the names and publishers of specific articles and asked to locate the articles. In the other two assessments, students were asked to locate information in order to answer the research question. Students also were prompted to type notes into a notepad as they read different articles on different websites.

Table 3.2

ORCA-II Items by Skill Area

| | |
|---|---|
| <i>Reading to Locate Online Information</i> | |
| 1. | Can the student locate the correct email message in an inbox or the correct section of a wiki? |
| 2. | Can the student use appropriate key words in a search engine? |
| 3. | Can the student locate the correct site in a set of search engine results? |
| 4. | Can the student identify correct website addresses in two different search tasks? |
| <i>Reading to Evaluate Online Information</i> | |
| 5. | Can the student identify the author of a website? |
| 6. | Can the student evaluate an author's level of expertise? |
| 7. | Can the student identify an author's point of view? |
| 8. | Can the student evaluate the reliability of a website? |
| <i>Reading to Synthesize Online Information</i> | |
| 9. | Can the student summarize an important element from one website? |
| 10. | Can the student summarize important elements from two websites? |
| 11. | Can the student summarize important elements from a second set of two websites? |
| 12. | Can the student summarize important elements from the websites in the research task to develop an argument? |
| <i>Writing to Communicate Online Information</i> | |
| 13. | Email Task: Does the student include the correct address line in an email message? Wiki Task: Does the student make a wiki entry in the correct location? |
| 14. | Email Task: Does the student include an appropriate subject line in an email message? Wiki Task: Does the student use descriptive voice in an informational wiki? |
| 15. | Email Task: Does the student include an appropriate greeting in an email message to an important, unfamiliar person? Wiki Task: Does the student include an appropriate heading for a new wiki entry? |
| 16. | Email Task: Does the student compose and send a well-structured, short report of their research, including sources, in an email? Wiki Task: Does the student compose and post a well-structured, short report of their research, including sources, in a wiki? |

Two formats and four skill areas in the ORCA-IIs. The ORCA-IIs included both a multiple-choice (ORCA-MC) and a closed, simulated, virtual Internet environment format (ORCA-Virtual). The ORCA-IIs included a set of eight assessments, with two different assessment formats for each of four life science topics: ORCA-MC and ORCA-Virtual. Only data from the ORCA-Virtual was used in the present study, since it demonstrated higher reliability across all four tasks. For the ORCA-MC, KR-20 values for each of Energy Drinks, Video Games, Snacks, and Contacts, respectively, were .73, .85, .77, and .80. For the ORCA-Virtual, KR-20 values for the same order of tasks were .88, .90, .86, .88 (Leu et al., 2014). Additionally, the ORCA-Virtual is more closely aligned with the kind of online research students would conduct outside of an assessment environment, since it simulates a real, online research process rather than containing multiple-choice questions.

Each format for the ORCA-IIs measured students' abilities in four skill areas important to online research and comprehension: locating (Bilal, 2000; Guinee, Eagleton, & Hall, 2003), evaluating (Sanchez, Wiley, & Goldman, 2006), synthesizing (Goldman, Wiley, & Graeser, 2005; Leu, et al., 2013; Jenkins, 2006), and communicating (Greenhow, Robelia, & Hughes, 2009). Each format consisted of sixteen items, with four component items in each of these four research and comprehension skill areas (see Table 3.2). The ORCA-Virtual measured all sixteen skills within a social networking site. After viewing a short email message from a virtual school board president, students were guided through the research process by two avatars, Brianna and Jordan. The investigation of Research Question 1 used data from students' scores in all four skill areas. The investigation of Research Question 2 used data from students' scores on the evaluation skill area only. All four skill areas included a total of four score points, with three

process score points and one product score point as the fourth and final score point within a given skill area. See Table 3.2 for descriptions of each score point.

The location skill area in the ORCA-IIs. The four Locate items on the ORCA-IIs measured students' ability to locate information during an online research and comprehension task. Specifically, the four score points measured students' ability to: 1) locate the email message in an inbox that is relevant to the research task or the relevant section of a wiki; 2) use appropriate key words in a search engine when searching for information relevant to a research task and when some parameters are provided (such as support for or against the topic of the specific research task or the name of a specific article; see Figure 3.1); 3) locate the correct website in a set of search engine results that is relevant to the search query requested by the avatars; and 4) identify the correct website addresses in two different search tasks. This last score point was derived; students had to identify both addresses correctly in order to earn a point.

Figure 3.1. The Gloogle Search Tool Used to Locate Information in the ORCAs



Rather than being asked sequentially, these score points were interspersed throughout the research task in an order that was logical and natural for the task. Locate 1 was asked first, followed by Synthesize 1, then Locate 2, Locate 3, Locate 4a (the URL for the first website), Synthesize 2, Locate 4b (the url for the second website), Synthesize 3, then all four Evaluate score points followed by all four Communicate score points.

In the Location portion of the ORCA-IIs, location was defined as the process of locating information that was relevant to and useful for a specific research task. This process included locating the relevant location of information in an email inbox or wiki, identifying and using appropriate key words in order to obtain relevant information, identifying a relevant website using headings and text in a set of search engine results, and determining whether the information at a selected site is useful after viewing and reading the actual site. The purpose of the Location skill area then was to identify information that was useful for developing an accurate understanding about the answer to a specific research question.

It is important to note that in the present assessment, the Locate skill area was separated as much as possible from the Evaluation skill area in order to determine students' abilities in these two skill areas separately. In actuality, Locate and Evaluate might be more closely tied to one another, as students needed to first locate relevant information before they can evaluate it. In the ORCA-IIs, however, students were provided with a link to a particular webpage that they were to evaluate. Therefore, students' ability to evaluate online information was not dependent upon their ability to locate a relevant webpage. See Table 3.3 for the scoring criteria for Locate. Note that scoring criteria for Locate was parallel across all four tasks, with the only differences being topic, type of task (Learn More About or Take a Position), and communication tool (email or wiki).

Table 3.3

Scoring Criteria for the Locate Scale for the Video Games and Eyesight Task

| Item | L1 | L2 | L3 | L4 |
|------------------|--|---|---|--|
| Purpose of Stem | Can the student locate the correct email message in an inbox or the correct section of a wiki? | Can the student use appropriate key words in a search engine? | Can the student locate the correct site in a set of search engine results? | Can the student correctly identify and share the website addresses from two different search tasks? |
| Item Stem | First, go to the wiki. Then, read the section on video games. When you are done, tell me you are finished. To go to the homepage of the wiki, <u>click here</u> . | Please use the Internet to find another website that says video games <u>help</u> your eyes. | Please use the Internet to find another website that says video games <u>help</u> your eyes. | Second url: Below send me the address, or link, of the website that you find. |
| Scoring Criteria | On the first search task, the student locates the correct email message (email) or wiki section (wiki) on the first click. Restricted and Unrestricted Tasks: Same criterion for both tasks. | On the first search task, student uses appropriate key words based on information provided by Brianna. Restricted (Energy Drinks and Contacts): On the first search task, the student uses appropriate key words, entering the article's title as the search term. Unrestricted Task (Video Games and Heart Healthy Snacks): On the first search task, the student uses appropriate key words, entering both topic and claim as search terms. | On the first search task, the student selects a correct site from the search results on the first click when the correct site is not in the first position. Restricted: For the first search task, did the student select the correct, target website from search results on the first click? Unrestricted: For the first search task, did the student select one appropriate site related to the topic from search results on the first click? | The student provides two correct website addresses from the two search tasks (scored on exact URL entry). Restricted: Did the student correctly provide both correct website addresses from the two search tasks? (scored on exact URL entry) Unrestricted: Did the student correctly provide two topically relevant website addresses from the two search tasks? (scored on exact URL entry). |

The synthesis skill area in the ORCA-IIs. The four Synthesize score points in the ORCA-IIs measured students' ability to synthesize information across multiple webpages during an online research and comprehension task. Students were provided with two of these webpages

and were asked to locate two of them. A fifth webpage was provided to students via a link as the webpage that they were to evaluate.

After being provided with the first webpage, students were asked to summarize one important idea from the webpage using a notepad tool (see Figure 3.2). Then, throughout the task, students were asked to summarize what they had learned on each of the three subsequent webpages using the notepad. After the first set of two webpages had been read, students were asked to synthesize what they had learned across the two webpages. After students read the second set of webpages, students were asked to synthesize again across the second set of two webpages (see Figure 3.3 for the third synthesis score point). Finally, students were asked to synthesize across all four webpages.

Figure 3.2. The Notepad Tool in the ORCA Used to Aid Students in Synthesizing Information Throughout the Task

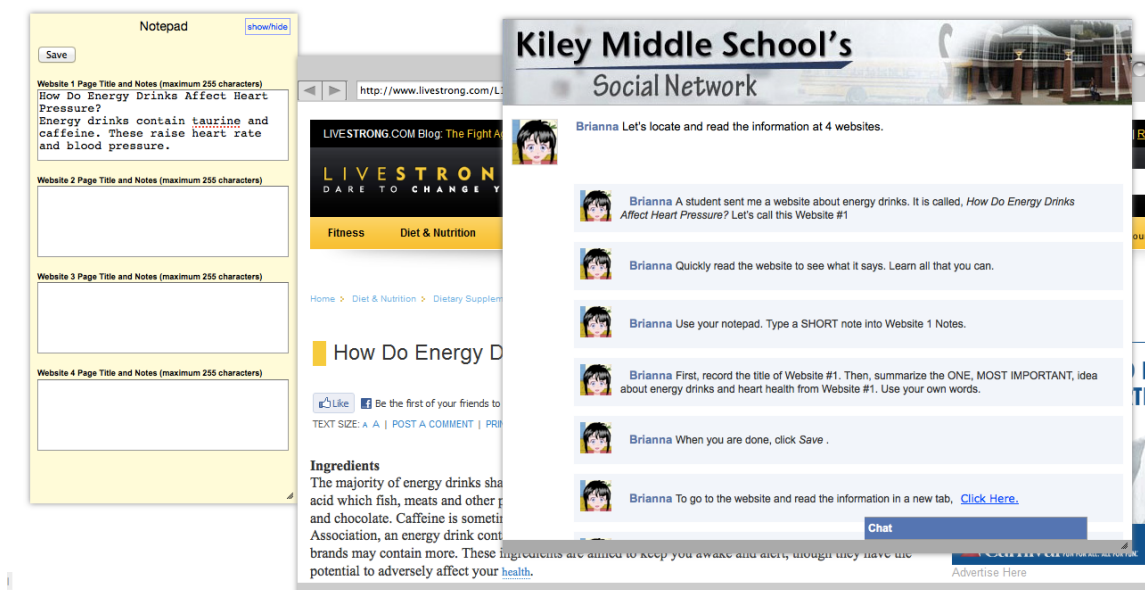
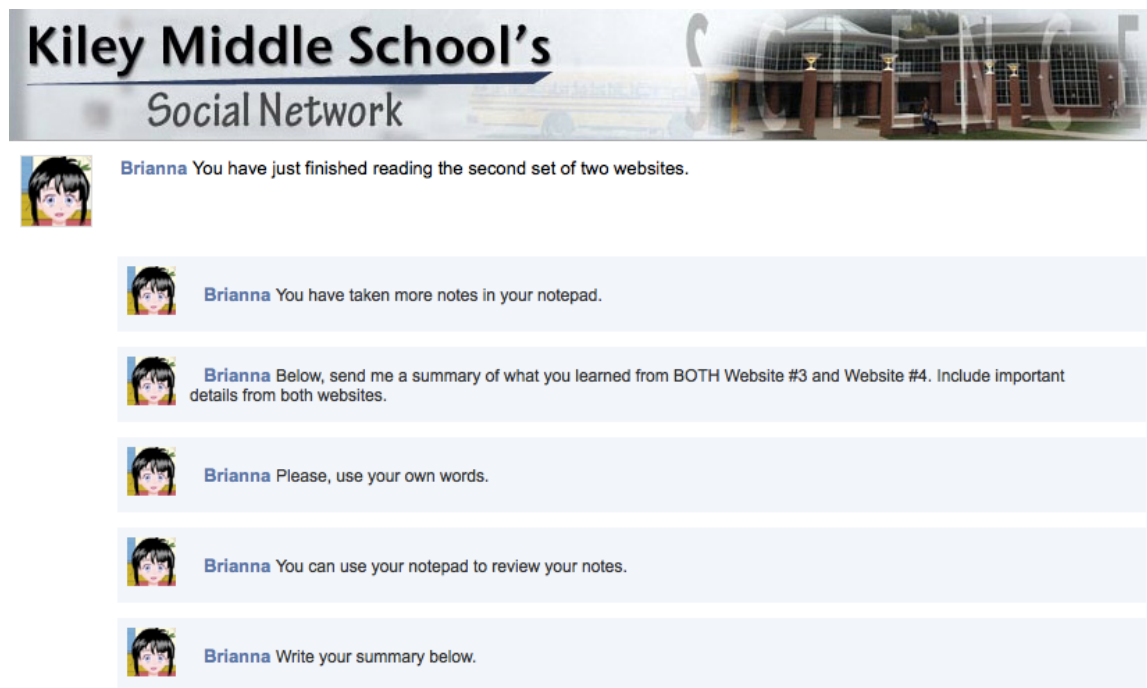


Figure 3.3. The Third Synthesis Score Point in the ORCA



The Synthesize score points measured students' ability to: 1) Summarize one important element from a webpage that was provided; 2) synthesize important information from one set of two webpages (one page that was provided and one that the student had to locate herself); 3) synthesize important information from a second set of two websites, and 4) synthesize important information from the research task to develop an argument (students were allowed to use information from the critical evaluation webpage as well as the four webpages from the rest of the task). As with the Locate skill area, these score points were interspersed throughout the task rather than being asked sequentially according to the logical sequence of the research process.

Here, synthesizing was defined as the process of summarizing and integrating information relevant to a specific research task across multiple texts. The exception to this was the first synthesis score point, which asked students to summarize information from only one

text. This was viewed as a first step in the process of synthesizing across multiple texts and so was included as the first score point to determine students' ability level in this skill area given a greater ability range. The purpose of the Synthesize skill area was for students to integrate relevant information across multiple texts in order to investigate and understand the answer to the given research question. See Table 3.4 for scoring criteria for Synthesize. Note that scoring criteria for Synthesize was parallel across all four tasks, with the only differences being topic (e.g., Video Games and Eyesight), type of task (Learn More About or Take a Position), and communication tool (email or wiki).

Table 3.4

Scoring Criteria for the Synthesize Scale for the Video Games and Eyesight Task

| Item | S1 | S2 | S3 | S4 |
|-----------------|--|---|---|---|
| Purpose of Stem | Can the student summarize an important element from one website? | Can the student summarize important elements from two websites? | Can the student summarize important elements from a second set of two websites? | Can the student summarize important elements from the websites used in the research task to develop an argument? |
| Item Stem | Summarize the ONE, MOST IMPORTANT, idea you found from Website #1 to support this claim: Video games help your eyes. Use your own words. | Below, send me a summary of what you learned from BOTH Website #1 and #2. Include important details from both websites. | Below, send me a summary of what you learned from BOTH Website #3 and Website #4. Include important details from both websites. | Now, take a position. Do video games <u>harm</u> your eyes? Send me a summary of what you think after reading all FOUR sites. Include important details from the websites that explain your thinking. |

| | | | | |
|------------------|---|--|---|---|
| Scoring Criteria | Does the student provide a summary of one important element from the first website using their own words (at least 3) that supports the given claim ("Video Games HELP your eyes"). Can be exact same as notepad because it is the notepad. | Using notes from the notepad or information from the sites themselves, can students use their own words (at least 3) to integrate one detail from each of the first two websites that supports the given claim ("Video Games HELP your eyes")? | Using notes from the notepad or information from the sites themselves, can students use their own words (at least 3) to integrate one detail from each of the second two websites that supports the given claim ("Video games HARM your eyes")? | Student uses own words (at least 3) to provide a claim/argument and one supporting detail from each of two different websites. Student uses own words (at least 3) to provide an argument (that takes a position) AND two pieces of evidence, one detail from each of two different websites. |
|------------------|---|--|---|---|

The communication skill area in the ORCA-IIs. The Communicate skill area measured students' ability in four component areas using either an email message tool (see Figure 3.4) or a classroom wiki tool (see Figure 3.5) that included: 1) communicating information in the correct and appropriate location of a given communication tool (either the correct address line in an email message or the correct location in a wiki); 2) communicating information using a tone appropriate for the tool and task (either an appropriate subject line in an email message or an appropriate, descriptive voice in a wiki entry); 3) communicating information with an appropriate awareness of audience (using an appropriate greeting in an email message or an appropriate heading in a wiki entry); and 4) communicating a short report of research findings that includes sources, using an email message or wiki. The purpose of the Communicate skill area was to communicate to others what the student had learned from the research process. The final score point needed to contain an argument with evidence from the webpages as well as the

sources where students obtained this information in order to earn a score point. See Table 3.4 for scoring criteria for Synthesize. Note that scoring criteria for Synthesize was parallel across all four tasks, with the only differences being topic (e.g., Video Games and Eyesight), type of task (Learn More About or Take a Position), and communication tool (email or wiki).

Figure 3.4. The Email Communication Tool in the ORCA

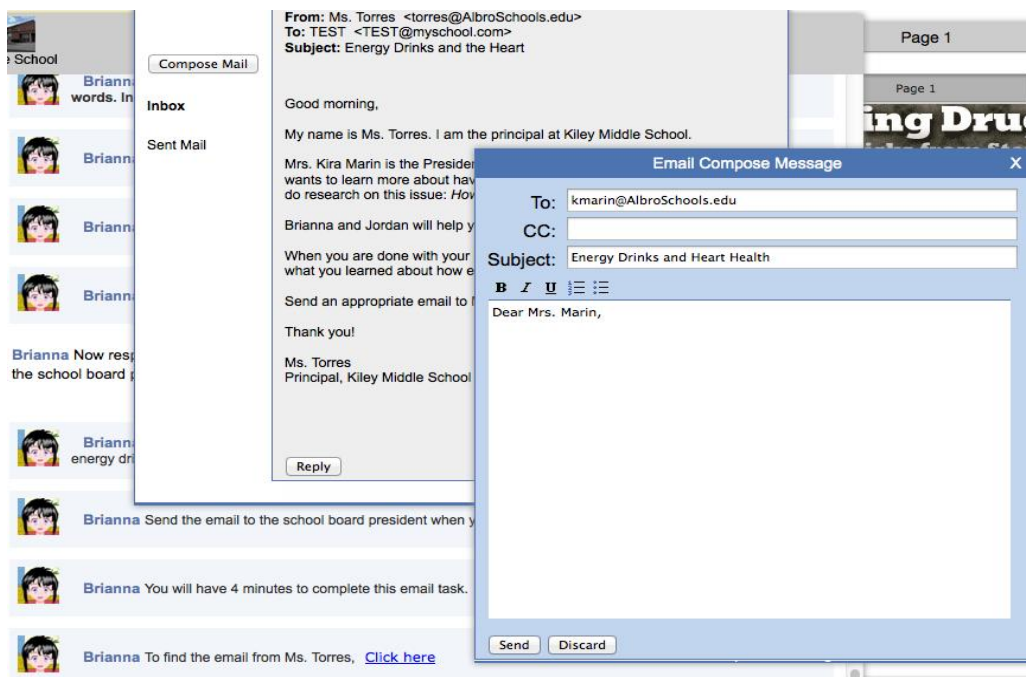


Figure 3.5. The Wiki Communication Tool in the ORCA: Mr. Henry's Classroom Wiki

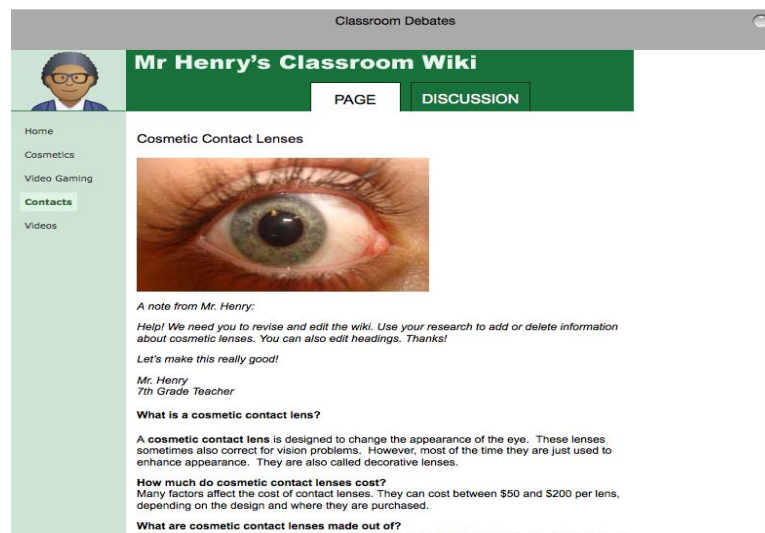
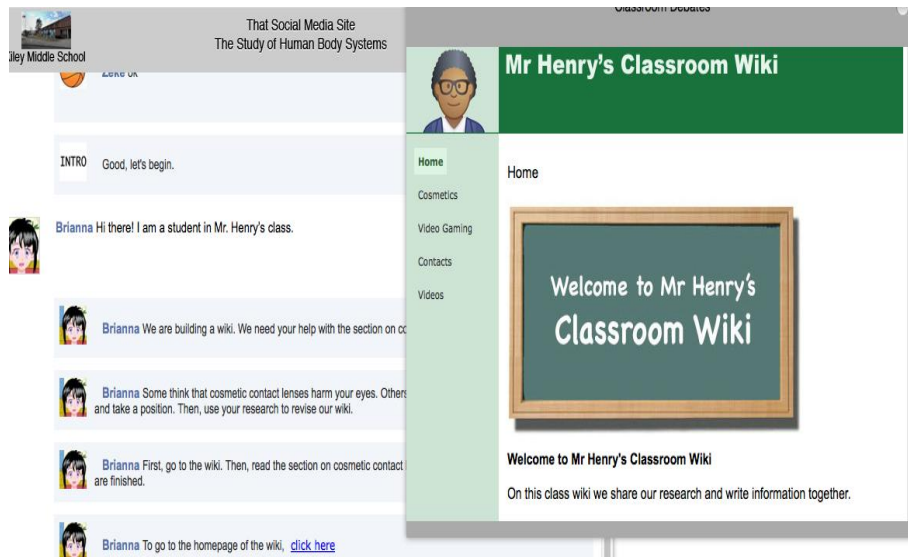


Table 3.5

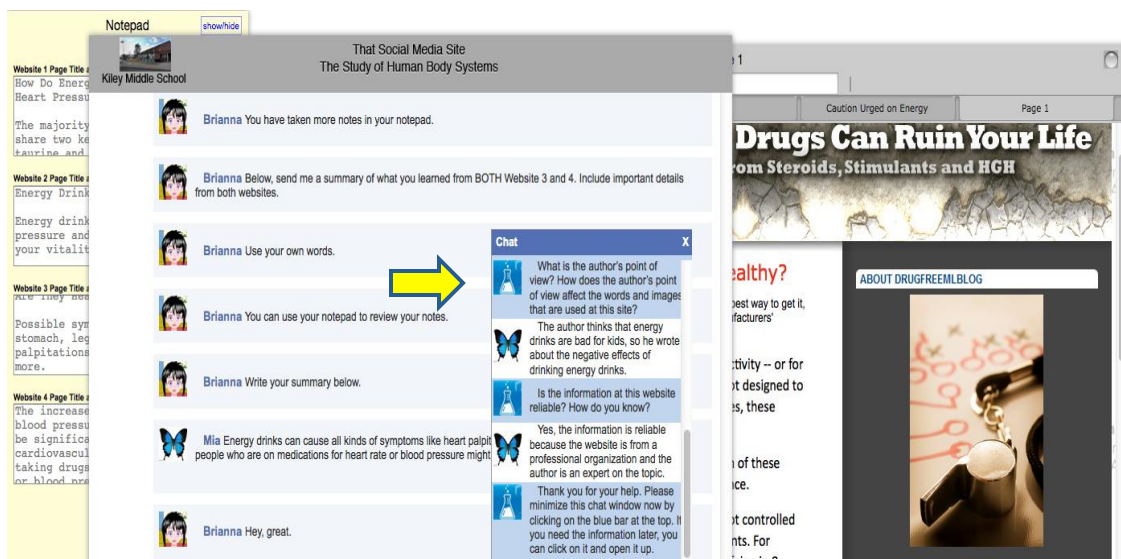
Scoring Criteria for the Communicate Scale for the Video Games and Eye Health Task

Now, write a short report on the class wiki. Use what you learned to add to the wiki for Mr. Henry and his students.

| Item | C1 | C2 | C3 | C4 |
|------------------|--|--|--|---|
| Purpose of Stem | Wiki Task: Does the student make a wiki entry in the correct location? | Wiki Task: Does the student use descriptive voice in an informational wiki? | Wiki Task: Does the student include an appropriate heading for a new wiki entry? | Wiki Task: Does the student compose and post a well-structured, short report of their research, including sources, in a wiki? |
| Item Stem | Now, write a short report on the class wiki. Use what you learned to add to the wiki for Mr. Henry and his students. | Now, write a short report on the class wiki. Use what you learned to add to the wiki for Mr. Henry and his students. | First, add a new heading in a location that makes sense. Then take a position: Do video games harm your eyes? | Be certain to explain your thinking. Use evidence from the websites that supports your position about the question: Do video games harm your eyes? Please include your sources. Use website titles. |
| Scoring Criteria | Student types a wiki entry in the correct location that includes any relevant content in the correct location, either: 1) below the other sections if no heading; 2) anywhere in the wiki below the Mr. Henry message if they do have a heading on a separate line | Student composes an informational wiki entry in a descriptive voice. | Student composes an appropriate heading in their wiki entry, containing both aspects of the topic (e.g., snacks and heart or health; video games and eyesight or eye health). An appropriate heading must be on a separate line. | Student composes and saves a wiki post with one relevant claim and two pieces of supporting evidence. They also include at least two sources, listing the names of the websites or the urls. |

The evaluation skill area in the ORCA-IIs. As with the other skill areas, the evaluation skill area included a total of four score points (one point for each of the four component skills). The four critical evaluation questions were asked in sequence with no other items between them. The four items were asked via a chat message window that pops over the social networking site. See Figure 3.6. All four evaluation score points in the ORCA-IIs measured students' ability to evaluate the credibility of the source of information found at the website. Specifically, the four score points measured students' ability to: 1) identify the author of a given website, 2) evaluate the author's expertise in relation to a specified research topic, 3) determine the author's point of view and one piece of written or visual evidence that matched that point of view, and 4) evaluate the overall reliability of the website. As students were investigating the credibility of the author in three of the four score points (the three "process" score points), they were directly examining source credibility.

Figure 3.6. Critical Evaluation Sequence Within the ORCA-II Virtual



In the Evaluation portion of the ORCA-IIs, critical evaluation of online information was defined as the process of investigating online information sources for the purpose of judging their credibility in relation to a specific research task. In this study specifically, this definition was limited to the use of critical evaluation in the context of an online research task, wherein one is searching for online information in order to solve a problem and communicate the solution to another. The purpose of critical evaluation in this context, therefore, is to develop an accurate understanding about the answer to a specific research question.

In order to obtain a point for the fourth Evaluation item, students needed to provide a reason for why they thought the site was reliable or not, and this reason needed to explain why they thought the author, publisher, and or information was credible. In this way, the scoring criteria for the evaluation section of the ORCA was closely aligned to the notion of argumentation, an important concept in science education (Duschl & Osborne, 2002; Newton, Driver & Osborne, 2000). In order to obtain a score point for the fourth evaluation item, evaluating the overall reliability of a website, students were required to evaluate the claims that the author of the given website made based on the observable evidence and/or logic that the author provided. In turn, students were further required to make a claim of their own about whether or not the website was reliable and to support this claim with justifiable evidence, again, important components of argumentation (Duschl & Osborne, 2002; Jimenez-Aleixandre & Erduran, 2008; Driver, Newton & Osborne, 2000). See Table 3.6 for scoring criteria for the Evaluation scale in the Eyesight task. Note that scoring criteria for Evaluate was parallel across all four tasks, with the only differences in criteria being different author names and article names for each task.

Table 3.6

Scoring Criteria for the Critical Evaluation Scale for the Video Games and Eye Health Task

| Item | CE 1 | CE 2 | CE 3 | CE 4 |
|------------------|---|---|--|---|
| Purpose of Item | Can the student identify the author of a website? | Can the student evaluate the author's level of expertise? | Can the student identify the author's point of view? | Can the student evaluate the reliability of a website? |
| Item Stem | Can you tell us who is the author or creator of this website, "Playing Video Games May Cause Eyestrain"? | Is Troy Bedinghaus an expert on video games or eye health? How do you know? | What is the author's point of view? What words or images does the author use to support that point of view? | Is the information at this website reliable? How do you know? |
| Scoring criteria | The student correctly identifies the author of the website (First, last, or first and last names accepted. Spelling variants accepted.) | The student judges the author's level of expertise AND provides an appropriate supporting detail about the author's level of expertise (or lack thereof). | The student identifies the author's point of view AND provides one accurate and specific piece of evidence from the webpage about words or images that supports this determination of the point of view. | The student evaluates the reliability of the website (or lack thereof) AND provides one logical and accurate explanation to support their conclusion about either: author expertise, publisher trustworthiness, or research findings. |

The online science texts used to measure critical evaluation in the ORCA-IIs. For each assessment format in the ORCA-IIs, there were four different life science topics that included

energy drinks and heart health, video games and eyesight, snacks and heart health, and cosmetic contact lenses and eyesight. The four Evaluation items in the ORCA-IIs required students to click on a link that took the student to a webpage. Students were then required to evaluate the reliability of information at that webpage. These four scientific webpage texts contained features typical of scientific text, including technical vocabulary, nominalizations, or verbs that have been made into nouns (Halliday & Martin, 1993), identifications, or definitions of technical terms, and attributions (Halliday, 1994), or terms that have been described by their placement within the context of other terms. For example, the Snacks and Heart Health webpage contains specialized vocabulary particular to the field of science, such as “calories” and “Kcals” (see Figure 3.7).

The four online Evaluation texts could be described as a science genre classified by Halliday & Martin (1993) as *explanation*. Texts that are classified as *explanation* explain how and why phenomena occur. The Video Games and Eye Health text, for example, explains how video games affect eyesight by explaining how eyes focus differently on a video screen compared to a flat surface, such as a piece of paper (see Figure 2.8).

Reliability. Previous studies on the ORCAs found that they demonstrated good reliability, with KR-20 ranging from .73 to .90 depending upon topic and format for the ORCA IIs (Leu et al., 2014). For the ORCA-MC, KR-20 values ranged from .73 to .85; for the ORCA-Virtual format, KR-20 values ranged from .86-.90 (Leu et al., 2014). KR-20 component values for the ORCA-Virtual for the present study were .56 for Locate, .43 for Evaluate, .67 for Synthesize, and .51 for Communicate.

Figure 3.7. The Snacks and Heart Health Webpage Used for the Evaluation Scale

The screenshot shows the HealthCentral MyHeartCentral.com website. At the top, there's a banner for LIPITOR with the text "NOW I EAT HEALTHIER, EXERCISE MORE, AND TAKE LIPITOR." and a "Roll over to watch" button. Below this is a navigation bar with a search box and links like "Find", "Manage", "Connect", "Free Newsletter", "Sign up now!", "My Home", "Sign In", and "Register Now". The main heading is "How to Makeover Your Unhealthy Snacks". Below the heading, there's a section for "Related: Heart Healthy Diet, More Tags>". An expert tip from Melanie Thomassian, dated Friday, June 06, 2008, is featured. The article text discusses snacking at 3:00pm and provides "Snacking guidelines". It states: "The most important thing to be aware of is the type of foods you're snacking on. It's wise to allow no more than 10% of your total day's calorie intake for high fat, or sugar items - that would be around 194 Kcal's for women, and 255 kcal's for men." It then lists criteria for healthy snacks: "Choose foods that don't contain too much fat, sugar or salt, and look out for those that provide you with more calcium, fiber, vitamins and minerals. Take a look at your food labels and try to choose those containing:" followed by a bulleted list: "• Fat content less than 3 grams per 100 grams", "• Sugar content less than 2 grams per 100 grams", and "• Sodium less than 0.1 grams per 100g". There are also LIPITOR advertisements on the right and bottom of the page.

Validity. The ORCA-II was developed as the third generation of the ORCA assessments. With each revision of the ORCAs, steps were taken to increase the validity of the assessment instrument.

Pre-pilot ORCA. For the pre-pilot ORCA, which was conducted in Year 2, a group of experts in reading comprehension, online research and comprehension, measurement, assessment, science education, and educational research developed an assessment framework (see tinyurl.com/p364zbs). The framework that was developed included a definition of online research and comprehension as well as an outline of the major skill areas in this research process: locating, evaluating, synthesizing, and communicating. This framework was used to develop the pre-pilot assessments. This development process included design meetings and cognitive labs

using think-aloud verbal protocols (Ericson & Simon, 1999; Willis, 1999) with over 300 seventh-grade students over two years. A panel of online research and comprehension experts then reviewed the proposed score points and suggested revisions.

ORCA-Is. A similar process was followed for the ORCA-Is and ORCA IIs. For the ORCA-Is, which were conducted in Year 3, a panel of experts in online research and comprehension reviewed the pre-pilot assessments and developed a set of parallel assessments in two additional formats that included Multiple-choice and Open Internet. Additional cognitive labs using a think-aloud process were conducted (Ericson & Simon, 1999; Willis, 1999) and used to further revise the assessments.

ORCA IIs. For the ORCA-IIs, which were conducted in Year 4, a panel of measurement experts reviewed the scoring data. A panel of online research and comprehension experts as well as measurement experts reviewed the data from the ORCA-Is and decided to drop the Open format in the final generation of ORCA (ORCA-IIs) for practicality and validity reasons. First, the Open Internet format cannot provide a stable Internet context, since it uses the Open and ever-changing Internet. Therefore, it was difficult to compare scores across testing times and locations. Additionally, the Open format was time consuming for students to take and for scorers to score and therefore much less practical to use than the other two formats. This same panel also reviewed the eight different topics used in the ORCA-IIs and decided to retain only the four topics that had the best reliability and validity estimates. The panel of online research and comprehension experts then used the data from the scores of the ORCA-Is to revise the assessment items to produce items that would further increase the reliability and validity of conclusions drawn from the data. For a more complete description of reliability and validity procedures, see Leu et al., 2014.

Prior Knowledge Measures

Prior to engaging in each ORCA-II, students completed a ten-item multiple-choice assessment designed to measure their prior domain knowledge on the science topic that was the focus of their assigned ORCA (either heart health or eye health – see Appendix A). Each student was assigned to one heart health ORCA-II and one eye health ORCA-II, so each student took both of the two possible prior domain knowledge measures. However, since the present study will only use data from the ORCA-Virtual, only the corresponding prior knowledge measures will be used. The prior domain knowledge measure was the same whether a student completed the ORCA-Virtual or the ORCA-Multiple-choice.

Validity. Validity was established through extensive cognitive labs over two years with approximately 300 students. We reviewed and discussed students' think aloud responses with them to determine the extent to which this approach provided a reasonable representation of their prior domain knowledge. We then made adjustments in this measure that included the use of a multiple-choice approach rather than a think aloud approach based on these experiences and based on a pilot test with approximately 1600 students. These adjustments allowed us to obtain a measure that was more comparable across students and testing situations.

Reliability. To date, there have been no studies of the reliability of the multiple-choice prior domain knowledge measure. KR-20 estimates for the present study were .27 for the Heart Prior Knowledge measure on the heart and .19 for the Prior Knowledge measure on Eyes.

Demographic Data: Gender and Socioeconomic Status

Prior to engaging in the ORCA-II assessment, students completed a brief set of demographic questions (see Figure 3.8). For both states, data on SES was collected at the school level using percent of students on free and reduced price lunches as a proxy measure of SES for

the school. Percent of students taking advantage of free and reduced price lunch in a school has been shown to be a valid proxy for school SES, as it is strongly and significantly correlated with the percent of families living in poverty in a given community, using other indicators of poverty (Nicholson, Slater, Chriqui, & Chaloupka, 2014).

Figure 3.8. The Demographic Data Collection Screen in the ORCA-IIs

Log In

Giuliana, please provide us with the following information:

My gender: Female

The primary language that is spoken at my house is: English

Continue

In the year in which the present study took place (the 2013-2014 school year), students qualified for reduced price lunches if their families had incomes at 185% or less below the federal poverty line. Students qualified for free lunches if their families had incomes at 130% or less below the federal poverty line. The federal poverty line differs depending on the number of people living in a household, but, as an example, in the school year of 2013-2014, the federal poverty line was \$23,500 for a family of four (U.S. Department of Agriculture, 2013).

Offline Reading Measures (ORMs)

The Offline Reading Measures, or ORM, were developed and validated during the pilot year of The ORCA Project. During the pilot year, four released passages and sets of test items

were selected from the National Assessment of Educational Progress (NAEP). NAEP tests are designed for grades 4, 8, and 12. NAEP items have been evaluated for their psychometric properties using IRT estimation techniques (e.g., two- and three-parameter logistic models).

In the pilot year study, two pairs of texts and their assessments came from grade 4: Blue Crabs and Wombats. Two pairs of texts and their assessments came from grade 8: Cheater Meters and Sharebots. Because the study population consisted of grade 7 students, we selected moderate and hard multiple-choice and short-constructed responses of the grade 4 materials. Pilot year data were used to select the most reliable and valid passages, representing a 7th grade difficulty level, for use in the Validation Year study: Blue Crabs (Grade 4) and Sharebots (Grade 8). Each participating student took a combined passage test that included both passages (see Appendix C for the full ORM, the combined passage test, that was administered for the Validation Year study).

Validity. In a prior analysis using pilot year data, exploratory factor analysis using a promax rotation was conducted for each of the two passages separately and confirmed that a one factor solution was appropriate for both passages (Cui, Bruner-Sedransk, & Sedransk, 2014). In this analysis, for the Blue Crabs passage, promax factor loadings indicated a range from .160 to .727 and, for the Sharebots passage, promax factor loadings indicated a range from .401 to .819.

Reliability. In another analysis using pilot year data, both the Blue Crabs and Sharebots passages were found to have a level of reliability that made them suitable for inclusion in a combined passage test (Cui, Bruner-Sedransk, & Sedransk, 2014). For the Blue Crabs passage, Cronbach's alpha for the raw score was .61 and for the standardized score was .62. For the Sharebots passage, Cronbach's alpha for both the raw and standardized scores was .57 (Cui, Bruner-Sedransk, & Sedransk, 2014).

Data Collection Procedures

Online Research and Comprehension Assessments (ORCAs)

Data were collected on each of two different assessment days. Students were randomly assigned to two different assessment topics (energy drinks, video games, snacks, or cosmetic contact lenses) as well as to two different formats (ORCA-MC or ORCA-Virtual). Format order was randomized. Due to some absences and technical difficulties, 214 students were unable to complete both assessments.

On each assessment day, students had about an hour to complete the assessment. Students who finished early were instructed to take out a book or other work and to work silently until everyone finished. In State A, two graduate students were the facilitators and in State B a team of six people were trained to facilitate with one facilitator assigned to each school. In both states, prior to each assessment, a brief set of formalized oral instructions were given to all students by the assessment facilitator.

The assessments took place on three sets of Macbook Airs, each of which included an automated startup feature. Students therefore only had to click on a “Go” button to start the assessment. Once a student clicked on the “Go” button, the automated startup feature ran QuickTime screen recording software in the background while students viewed the assessment context in the foreground. Data from each assessment was saved automatically by the ORCA system so that scorers could later view the data for scoring.

Prior Knowledge Measures

Once they have logged into the ORCA system, and prior to being directed to the actual ORCA-II, students were required to answer the ten-item, multiple-choice, prior domain knowledge measure. Once they had responded to all items and had clicked on a “submit” button,

the system then advanced them to the ORCA-II. If a student skipped a question, they were directed to respond to the skipped item before being advanced to the ORCA-II. The system would not advance students to the ORCA-II until they had selected an answer choice for all ten prior knowledge items.

Demographic Data: Gender and Socioeconomic Status

When students logged into the ORCA system with their unique identification number (provided by the ORCA system once a test administrator had registered the student; see Figure 3.9), they were first taken to a series of demographic questions that included gender. This included selecting their gender from a drop-down menu that included “male” or “female.”

Data on SES was collected at the school level, using percent of students taking free and reduced price lunch as a proxy measure for SES. This data was obtained from the state department of education websites for each of the two states involved in the present study.

Figure 3.9. The Login Screen for the ORCA-IIs

Log In

Enter Your ID Number Here:

Welcome, Giuliana B.

*If you are not Giuliana B, try re-entering your ID number or ask a monitor to assist you. Otherwise click the **continue** button.*

Offline Reading Measures (ORMs)

Students completed an offline reading measure, or ORM, in between the two ORCA assessment days (see Appendix C for the measure). The ORM was a paper test completed using a pen or pencil. The ORCA test facilitator distributed the ORMs to each teacher on the first day of ORCA testing and collected the completed ORMs on the second day of ORCA testing.

Scoring

Online Research and Comprehension Assessments-II (ORCA-IIs)

Both formats were scored using a binary (0-1) scoring system. For the multiple-choice ORCAs, all assessment data was automatically scored by the ORCA scoring system according to pre-loaded correct answer formulas. For the Virtual ORCAs, all assessment data was saved in the ORCA scoring system (see Figure 3.10) and then downloaded to an Excel file with pre-loaded formulas for scoring. Depending on the assessment format and topic, about half of the items were automatically scored for each assessment. A team of four trained undergraduate scorers (one for each topic) then hand scored the remaining items for each assessment in their own separate scoring sheet. For the critical evaluation items, the first score point (identify the author) was automatically scored by the ORCA scoring system while the remaining three score points (evaluate author expertise, describe author point of view, and evaluate the overall reliability of the website) were all scored by an undergraduate. Once all responses had been scored, the Excel data sheets were then uploaded to a File Maker Pro database, where all data for the project is stored.

Scorers were trained to 90% accuracy, for each item, on their assigned topic before being permitted to begin formal scoring. Twenty percent of each scorer's scores were randomly checked for accuracy by two graduate scoring experts. The graduate scoring experts previously

had been trained and tested in a similar manner as that of the rest of the scorers. Scorers were retrained and retested before they could continue scoring if they fell below this accuracy percentage.

Figure 3.10. A Portion of A Score Report in the ORCA Scoring System

Report #1131

LESC 3 closed

Info

Event Log

Prior Knowledge

choose variable set:

Enter a name for new set

edit

delete

new

| event | event_code | text | thread_id | entry_id |
|-------|-------------------------|--|-----------|---------------------------|
| 17 | show_system_entry | INTRODUCTION | Warning | untitled_0 |
| 18 | show_system_entry | In this activity, you will be chatting with students from Turner Middle School who have been approved to participate. It is perfectly safe to chat with them. When you are ready, type OK below. | Warning | Context |
| 19 | FBCB_onBtnClick_comment | ok | Warning | Context_user_response |
| 20 | show_system_entry | Thanks. | Warning | Context_end |
| 21 | show_system_entry | How can snacks be heart-healthy?In this activity, you will do research to answer this question.Then, you will be asked to write an email, and tell someone about your research. | Context | undefined_1 |
| 22 | show_system_entry | You will have about 45 minutes to complete all of the activities.When you are ready, type OK below. | Context | undefined_2 |
| 23 | FBCB_onBtnClick_comment | ok | Context | undefined_2_user_response |
| 24 | show_system_entry | Good, let's begin. | Context | Context_end_3 |

Prior Knowledge Measures

Students' responses for the prior domain knowledge measures were scored automatically by the ORCA scoring system. These scores were then downloaded into an Excel spreadsheet and imported into a File Maker Pro database.

Offline Reading Measures (ORMs)

For the Blue Crabs passage, all six items were scored using dichotomous scoring (using 0 or 1 points). For the Sharebots passage, two items were polytomously scored (using 0, 1, or 2 points) while the rest of the items (five, in all) were scored using dichotomous scoring. For both

passages, the total score for each passage was calculated by summing the score points for each item to determine an overall total. See Appendix D for scoring guide.

The ORMs were scored by two senior undergraduate students who were trained by two graduate student expert scorers. The senior undergraduate scorers were trained to 90% accuracy, with an expert scoring randomly checking 20% of their scores to be sure that the 90% accuracy threshold was consistently met. In the few cases where 90% accuracy was not met, the expert scorer and the undergraduate scorer discussed the scores in order to come to a resolution. The undergraduate scorer was retrained and retested to meet 90% accuracy before moving on to score the remainder of the items. Each ORM scorer scored all items for one of the two passages, with one student scoring all Blue Crabs items and one scoring all Sharebots items. Scorers placed scores into Excel spreadsheets, which were then uploaded into the File Maker Pro database.

Analysis

For all analyses in the present study, student scores from both State A and State B were combined after prior analyses revealed that there was no difference in student scores between states (Forzani, Maykel, Flake, & Leu, in preparation). As such, State was not included as a level in any of the multilevel analyses.

Research question 1: Exploring the Nature of Students' Ability to Critically Evaluate in Relation to Students' Ability to Locate, Synthesize, and Communicate During Online Reading in Science

The first research question was investigated in two different ways, using a separate analysis for each, to provide a more complete picture of the investigation. In the first approach, an analysis of shared variance involving four separate regression analyses was used to investigate the extent to which elements found in the critical evaluation construct are also found

in the locate, synthesize, and communicate constructs. First, Locate, Evaluate, and Synthesize were entered into three, separate, simple regression models as the sole predictor with Evaluate Total as the outcome variable. Then, for the fourth regression analysis, all three skill area totals (Locate Total, Synthesize Total, and Communicate Total) were entered into a multiple regression model together, again with Evaluate Total as the outcome variable.

In the second approach for investigating the first research question, three separate, two-level multilevel models were used to evaluate the relative difficulty of the Critical Evaluation construct in relation to the Locate, Synthesize, and Communicate constructs. Each of the four constructs used in the analyses was measured by each of the four skill area scales (Locate, Evaluate, Synthesize, and Communicate) on the ORCA. This analysis treated schools/classrooms as Level 2 and students as Level 1. The dependent variable was, for each of the three analyses, a composite variable that was the mean difference of each skill area score to the Evaluate skill area score for each student, with the Evaluate score subtracted from the skill area score in each case (e.g., the “L-E” variable showed, for each student, his or her Locate score minus his or her Evaluate score; the “S-E” variable was a calculation of the difference between Synthesis and Evaluate for each student, and the “C-E” variable a calculation of the difference between Communicate and Evaluate for each student).

Research question 2: Investigating the Effects of Prior Knowledge, Gender, SES, and Offline Reading Ability on Students’ Ability to Critically Evaluate Online Information

The second research question used a two-level model to investigate the extent to which prior knowledge, gender, SES, and offline reading ability contribute to students’ critical evaluation abilities. This analysis treated schools/classrooms as Level 2 and students as Level 1. Prior knowledge, gender, SES and offline reading ability served as the independent variables and

students' scores on overall critical evaluation (out of four possible score points) as the dependent variable. See Table 3.7 for an overview of the methodology and data analysis methods for the two research questions.

Table 3.7

Methodology and Data Analysis Methods for the Two Research Questions

| RQ# | Research Question | Methodology | Analysis Method |
|-----|--|---|---|
| 1 | What is the nature of students' ability to critically evaluate online information in relation to three other skill areas also required during online reading in science? | Analysis of shared variance (first analysis) Multilevel Modeling (second analysis) | <i>Regression Analysis:</i> IVs: Locate, Total, Synthesize Total, and Communicate Total DV: Evaluate Total <i>Two-level modeling:</i> IVs: skill area (Locate, Evaluate, Synthesize and Communicate) DV: mean differences for each of the three skill areas compared to Evaluate |
| 2 | During online reading in science, to what extent do prior knowledge, gender, SES, and offline reading ability contribute to students' ability to critically evaluate the credibility of online source information? | Multilevel Modeling | <i>Two-level modeling:</i> IVs: Student level: prior knowledge, gender, offline reading ability, School-level: school means for prior knowledge, gender, offline reading ability, and school SES DV: overall critical evaluation score (out of four points) |

Note: IV is independent variable; DV is dependent variable; SES is socioeconomic status as measured by free and reduced price lunch by school.

Evaluating Missing Data

Two sets of analyses were conducted to estimate the impact of missing data. Of 1,769 students for whom there was data, 164 did not take an ORCA-Virtual (only an ORCA Multiple Choice). An additional 146 students had only partial ORCA-Virtual data. Finally, an additional 25 students did not take an Offline Reading Measure. All students with complete ORCA-Virtual data also had complete Prior Knowledge data, since students had to complete the Prior Knowledge assessment as well as the gender questionnaire prior to the automated ORCA system initiating an assigned ORCA. There was no missing data for FRPL as this data was published for each school by each state and was readily available online. Only students with complete data for the ORCA-Virtual and the Offline Reading Measure were included in the analysis.

The first set of analyses included five t-tests that compared students who did not have any ORCA-Virtual data (but who had ORCA-MC data) with those students who had complete, ORCA-Virtual data. These two sets of students were compared on five variables: Prior Knowledge, Gender, Offline Reading, FRPL, and their total ORCA-Multiple Choice scores.

The second set of analyses included a set of five t-tests that compared students with partial ORCA-Virtual data to students with complete ORCA-Virtual data. These two sets of students were compared on five variables: Prior Knowledge, Gender, Offline Reading, FRPL, and Locate. Locate alone was used rather than the entire ORCA score or a combination of ORCA scale scores (Locate, Evaluate, Synthesize, and Communicate) since Locate was the only scale for which all students who had only partial ORCA-Virtual data had complete data.

Limitations

While the present study has several limitations, steps were taken to limit the exposure of these threats to validity. One potential limitation was the possibility of a difference between

students with no or only partial ORCA-Virtual data and those who had complete ORCA-Virtual data. To determine if there were differences that might affect the analyses, scores from students with missing data were compared to scores from students with complete data to determine if there was an effect for attrition. These results showed that there were no differences.

Another limitation was the degree of external validity. While findings can be generalized to each of the two state populations since participating schools were stratified by SES, geographic location, and offline reading score to be representative of the larger state population, findings cannot be generalized to other states. However, participants have been described in as much detail as possible so that readers may determine the extent to which the findings might relate to their own populations of interest.

Finally, one important limitation to consider is the internal consistency reliability scores for each of the four skill areas (KR-20s were .56 for Locate, .43 for Evaluate, .67 for Synthesize, and .51 for Communicate) as well as for the Prior Knowledge measure (KR-20 estimates were .27 for Heart and .19 for Eyes). These were relatively low, potentially indicating multidimensional measures for each of these constructs. Therefore, the results should be considered in relation to these scores, as these low reliabilities may affect the validity of the scores. However, it is also important to keep in mind that the relatively low KR-20 estimates may be due in part to the short length of each measure (Tang, Cui, & Babenko, 2014). Therefore, inclusion of only four items for each of these scales for the skill area estimates, in particular, may have affected the internal consistency reliability estimates. The same may be true for the prior knowledge measures.

CHAPTER IV

RESULTS

Research Question 1: Comparing Critical Evaluation to Location, Synthesis, and Communication

The First Set of Analyses for Research Question 1

The first research question was investigated using two different approaches in order to provide a broader perspective of the relationship between the online reading skill area of critical evaluation and three related online reading skill areas that included location, synthesis, and communication. First, an analysis of shared variance involving four separate regression analyses was used to investigate the extent to which elements found in the critical evaluation construct were also found in the Locate, Synthesize, and Communicate constructs. This analysis fleshes out a picture of the extent to which these four skill areas overlap, thus providing an important context for interpreting the subsequent analyses.

For the first approach, four regression analyses were conducted. First, Locate Total, Synthesize Total, and Communicate Total were entered into three, separate, simple regression models as the sole predictor with Evaluate Total as the outcome variable. Then, all three skill area totals (Locate Total, Synthesize Total, and Communicate Total) were entered into a multiple regression model together with Evaluate Total as the outcome variable.

Prior to conducting the regression analyses, all scores for the four skill areas of Locate, Evaluate, Synthesize, and Communicate were examined for fit between their distributions and the assumptions of regression analysis. Examination of the residual plots determined variable distributions satisfied assumptions of linearity, homoscedasticity, and multivariate normality (see

Tabachnick & Fidell, 2013). In addition, collinearity diagnostics of the bivariate correlations between the variables indicated no issues with relation to multicollinearity.

The means and standard deviations for all variables in the regression analyses are presented in Table 4.1 along with Cronbach's alpha for the four skill areas. The percentages of students scoring correctly on Evaluate Total as well as on each of the four individual Evaluate score points are presented in Table 4.1, and the intercorrelations among the variables are presented in Table 4.3.

Table 4.1

Means and Standard Deviations for the Four Skill Areas, the Four Individual Evaluate Score Points, and the Individual Difference Variables

| Dependent and Independent Variables | M (SD) | Cronbach's Alpha |
|--|---------------|------------------|
| <i>Research Question 1</i> | | |
| Evaluate Total (out of 4 points) | 1.51 (.98) | .44 |
| Evaluate 1 (out of 1 point) | .83 (.38) | |
| Evaluate 2 (out of 1 point) | .23 (.42) | |
| Evaluate 3 (out of 1 point) | .31 (.46) | |
| Evaluate 4 (out of 1 point) | .15 (.36) | |
| Locate Total (out of 4 points) | 1.85 (1.23) | .56 |
| Synthesize Total (out of 4 points) | 2.41 (1.35) | .66 |
| Communicate Total (out of 4 points) | 1.05 (1.08) | .49 |
| Locate – Evaluate (out of 4 points) | .342 (1.39) | |
| Synthesize – Evaluate (out of 4 points) | .901 (1.37) | |
| Communicate – Evaluate (out of 4 points) | -.463 (1.30) | |
| <i>Research Question 2</i> | | |
| Prior Knowledge (out of 10 points) | 4.73 (1.63) | |
| Gender (out of 1 point) | .49 (.50) | |
| Offline Reading (out of 15 points) | 9.32 (3.05) | |
| School Mean for Prior Knowledge (out of 10 points) | 4.73 (.489) | |
| School Mean for Gender (out of 1 point) | .49 (.084) | |
| School Mean for Offline Reading (out of 15 points) | 9.32 (1.23) | |
| School FRPL (out of 100 points) | 39.12 (23.33) | |

N = 1,434. Note: A 100 point FRPL score indicates that 100% of children at a given school received free or reduced price lunch.

Overall, students were not especially skilled at the four online research skill areas of Locate Total (M = 1.85; SD = 1.23), Synthesize Total (M = 2.41; SD = 1.35), Evaluate Total (M

= 1.51; SD = .98) and Communicate Total (M = 1.05; SD = 1.08). There were four total possible score points for each skill area.

Students were particularly unskilled at evaluating the reliability of online information. Only 4% of students scored correctly on all four Evaluate score points, and 12.8% of students could not answer any of the Evaluate items. Of the four individual score points, 82.7% were able to identify the author of a webpage (Evaluate 1), 22.5% could evaluate the author's expertise (Evaluate 2), 31% could evaluate the author's point of view (Evaluate 3), and only 15% could evaluate the overall reliability of the information at a given webpage. See Table 4.2.

Table 4.2

Percentage of Students Scoring Correctly On the Critical Evaluation Items

| Evaluate Component | Percentage of Students Scoring Correctly |
|--|--|
| Evaluate Total (out of 4 score points) | |
| 4 score points correct | 4.0 |
| 3 score points correct | 11.6 |
| 2 score points correct | 28.8 |
| 1 score point correct | 42.9 |
| 0 score points correct | 12.8 |
| Individual Evaluate Score Points (out of 1 point each) | |
| Evaluate 1 (identify the author) | 82.7 |
| Evaluate 2 (evaluate author's expertise) | 22.5 |
| Evaluate 3 (evaluate the author's point of view) | 31.0 |
| Evaluate 4 (evaluate overall reliability of the webpage) | 15.0 |

Bivariate correlation statistics in Table 4.3 show that each skill area had relatively small but positive and significant correlations with Evaluate. For Locate and Evaluate, $r = .229$, $p < .01$; for Synthesize and Evaluate, $r = .352$, $p < .01$, and for Communicate and Evaluate, $r = .245$, $p < .01$.

Table 4.3

Bivariate Pearson Correlations Among Dependent and Independent Variables

| Dependent and Independent Variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 11 | 12 | 13 | 14 |
|-------------------------------------|---------|---------|---------|---------|---------|--------|---------|---------|---------|---------|----|
| <i>Dependent Variable</i> | | | | | | | | | | | |
| 1. Evaluate | 1 | | | | | | | | | | |
| <i>Independent Variables</i> | | | | | | | | | | | |
| 2. Locate | .229** | 1 | | | | | | | | | |
| 3. Synthesize | .352** | .298** | 1 | | | | | | | | |
| 4. Communicate | .245** | .230** | .224** | 1 | | | | | | | |
| 5. Student-Level Prior Knowledge | .186** | .158** | .233** | .137** | 1 | | | | | | |
| 6. Student-Level Gender | -.083** | -.083** | -.229** | -.055* | .026 | 1 | | | | | |
| 7. Student-Level Offline Reading | .351** | .217** | .373** | .276** | .230** | -.013 | 1 | | | | |
| 8. School Mean PK | .166** | .108** | .185** | .131** | .300** | .003 | .187** | 1 | | | |
| 9. School Mean Gender | -.030 | -.014 | -.030 | .024 | .005 | .167** | .072** | .018 | 1 | | |
| 10. School Mean Offline Reading | .234** | .135** | .211** | .165** | .139** | .030 | .404** | .462** | .178** | 1 | |
| 11. School Mean FRPL | -.086** | -.114** | -.132** | -.113** | -.176** | -.029 | -.186** | -.587** | -.174** | -.461** | 1 |

**Correlation is significant at the .01 level (two-tailed).

*Correlation is significant at the .05 level (two-tailed).

Results of the first regression analysis (see Table 4.4) indicated that, on its own, Locate accounted for 5.2% of the variance in Evaluate Total, which was significant, $F(1, 1433) = 79.268, p < .001$. The unstandardized beta was .183, $t = 8.903, p < .001$. Results of the second regression analysis (see Table 4.5) indicated that Synthesize accounted for 12.3% of the variance in Evaluate Total, which was significant, $F(1, 1433) = 202.507, p < .001$. The unstandardized beta was .257, $t = 14.230, p < .001$. Results of the third regression analysis indicated that Communicate for accounted for 5.9% of the variance in Evaluate Total, which was significant as well, $F(1, 1433) = 91.299, p < .001$. The unstandardized beta was .225, $t = 9.555, p < .001$.

Table 4.4

Regression Analyses of the Individual Locate, Synthesize, and Communicate Skill Areas on the Evaluate Skill Area

| Dependent and Independent Variables | R | Adjusted R^2 | F | Unstandardized β |
|-------------------------------------|------|----------------|---------|------------------------|
| Evaluate | | | | |
| Synthesize | .352 | .123 | 202.51* | .257* |
| Communicate | .245 | .059 | 91.30* | .225* |
| Locate | .229 | .052 | 79.27* | .183* |

Note. * $p < .005$

For the multiple regression, results were significant and indicated that together, Locate Total, Synthesis Total, and Communicate Total accounted for 16.2% of the variance in Evaluate Total, $F(3, 1433) = 93.01, p < .001$. Synthesize Total contributed the most (standardized beta = .29, $t = 11.08, p < .001$), then Communicate Total (standardized beta = .16, $t = 6.19, p < .001$), then Locate Total (standardized beta = .11, $t = 4.21, p < .001$).

Table 4.5

Multiple Regression Analysis of the Locate, Synthesize, and Communicate Skill Area on the Evaluate Skill Area

| Dependent and Independent Variables | R | Adjusted R ² | F | Unst. β | St. β |
|-------------------------------------|------|-------------------------|--------|---------------|-------------|
| Evaluate | | | | | |
| Synthesize, Communicate, Locate | .404 | .162 | 93.01* | | |
| Synthesize | | | | .21* | .29* |
| Communicate | | | | .14* | .16* |
| Locate | | | | .09* | .11* |

Note. *Unst.* = Unstandardized; *St.* = Standardized.

Summary of the first set of analyses for Research Question 1. The first set of analyses examined the nature of the critical evaluation construct compared to those of the Location, Synthesis, and Communication constructs using four regression analyses. The first three analyses, simple regression analyses, examined the shared variance between each of three skill areas (Locate, Synthesize, and Communicate) and the Evaluate skill area, with Evaluate Total regressed on each of the three predictors separately. The results of these analyses were all significant and revealed that Locate accounted for 5.2% of the variance in Evaluate Total, Synthesize Total accounted for 12.3% of the variance, and Communicate accounted for 5.9%. For the fourth analysis, a multiple regression analysis, Locate Total, Synthesize Total, and Communicate Total were entered into the model together. Then, Evaluate Total was regressed on these three skill areas together. Together, these three predictors accounted for 16.2% of the variance in Evaluate Total, which was significant.

The Second Set of Analyses for Research Question 1

For the second approach for investigating the first research question, three separate, two-level multilevel models were used to evaluate the relative difficulty of the Critical Evaluation construct in relation to the Locate, Synthesize, and Communicate constructs, as measured by each of the four skill area scales (Locate, Evaluate, Synthesize, and Communicate) on the ORCA. Multilevel analyses are useful when accounting for the effects of multiple levels of data, as is the case in the present study where different students were nested within different schools. The multilevel analyses allowed for an investigation of the effects of the school on the skill area scores.

In these three analyses, students (Level 1) were nested within schools (Level 2). Each analysis used, as its outcome measure, a composite variable that was the mean difference of each skill area score to the Evaluate skill area score for each student, with the Evaluate score subtracted from the skill area score in each case (e.g., the “L-E” variable showed, for each student, his or her Locate score minus his or her Evaluate score; the “S-E” variable was a calculation of the difference between Synthesis and Evaluate for each student, and the “C-E” variable a calculation of the difference between Communicate and Evaluate for each student).

In order to provide the necessary variance estimates to calculate the proportion of variance that was between students/within school and between schools (i.e., the intraclass correlation coefficient, or ICC), none of the three models contained predictors. The first analysis, using *L-E* as the outcome measure, revealed that of the variance in the mean difference between Locate and Evaluate, 97.7% was within schools/between students, which was a significant calculation. Only 2.25% of the variance occurred between schools, though this was not significant. The other two analyses revealed similar results, with the *S-E* analysis showing

99.25% of the variance in the mean difference of Evaluate compared to Synthesis occurring within schools/between students, which was significant, and only .74% occurring between schools. Again, the between school variance was not significant. Finally, the analysis using *C-E* as the outcome measure showed that 97% of the variance occurred within school/between students and was significant and 2.7% occurred between schools. Again, the between school variance was not significant. See Table 4.6 for estimates.

Table 4.6

Parameter Estimates for Fixed and Random Effects for Unconditional Models of the Difference Between Each Skill Area and the Evaluate Skill Area

| Dependent Variable | Fixed Effects Intercept | Random Effects Residual | Random Effects Intercept | Within School Variance | Between School Variance |
|----------------------|-------------------------|-------------------------|---------------------------|------------------------|-------------------------|
| Locate-Evaluate | .367* (.050) | 1.90* (.072) | .044 ^{NS} (.022) | .977 | .023 |
| Synthesize-Evaluate | .902* (.041) | 1.85* (.070) | .014 ^{NS} (.015) | .993 | .007 |
| Communicate-Evaluate | -.445* (.048) | 1.57* (.060) | .043 ^{NS} (.021) | .970 | .027 |

Note: Results are based on data from 1,434 students distributed across 40 classroom sites. Standard errors are in parentheses. A Bonferroni correction was used to control for Type I error at the .05 level. * $p < .05$. ^{NS} is not significant.

Additionally, these analyses revealed that students performed significantly better on both Locate ($M = 1.85$; $SD = 1.23$) and Synthesize ($M = 2.41$; $SD = 1.35$) than they did on Evaluate ($M = 1.51$; $SD = .98$). However, students performed more poorly on Communicate ($M = 1.05$; $SD = 1.08$) than they did on Evaluate. See Table 4.1 for mean differences. For all three sets of analyses, a Bonferroni correction was applied separately to each set to control for the familywise

Type I error within each set, given that three separate sets of analyses were used. A Bonferroni correction is one of the most conservative and simple approaches when controlling the familywise error rate (Abdi, 2007).

Summary of the second set of analyses for Research Question 1. The second set of analyses that investigated the first research question included three separate, two-level multilevel models. In these models, students (Level 1) were nested within schools (Level 2). These models were used to investigate the relative difficulty for students of the Evaluate skill area in relation to the Locate, Synthesize, and Communicate skill areas. For each of the three analyses, the dependent variable was a composite variable that was the mean difference between Evaluate Total and each of the skill area totals. These models demonstrated that, of the variance in the mean difference between each skill area total and Evaluate Total, 97.7 was within schools for Locate and 97% within schools for Communicate, both of which were significant. The within school variance was not significant for Synthesize. The between school variance was not significant for any of the analyses. These analyses also showed that students performed significantly better on both Locate and Synthesize compared to Evaluate but that they performed more poorly on Communicate.

Summary of Results for Research Question 1

To answer Research Question 1, which compared scores on Critical Evaluation Total to scores on Location Total, Synthesis Total, and Communicate Total, two sets of analyses were conducted. The first set of analyses used four regression analyses. The second set of analyses used three separate, two-level multilevel models.

For the regression analyses, the first three analyses examined the shared variance between each of the three skill areas (Locate Total, Synthesize Total, and Communicate Total)

and the Evaluate skill area. The results of these analyses were all significant and revealed that Locate accounted for 5.2% of the variance in Evaluate Total, Synthesize Total accounted for 12.3% of the variance, and Communicate accounted for 5.9%. The fourth analysis, which included Locate Total, Synthesize Total, and Communicate Total as predictors and Evaluate Total as the dependent variable, revealed that together, the three skill area predictors accounted for 16.2% of the variance in Evaluate Total, which was significant.

For the multilevel models, students (Level 1) were nested within schools (Level 2). Each of the three separate analyses used as its outcome measure the mean difference between each skill area total and Evaluate Total. These models demonstrated that, of the variance in the mean difference between each skill area total and Evaluate Total, 97.7% was within schools for Locate and 97% within schools for Communicate, both of which were significant. The within school variance was not significant for Synthesize. The between school variance was not significant for any of the analyses. These analyses also showed that students performed significantly better on both Locate and Synthesize compared to Evaluate but that they performed more poorly on Communicate.

Together, these two sets of analyses show that, in the ORCA-II Virtual, Critical Evaluation was a unique and difficult skill area for students and that much of this difficulty related to within-school differences. Overall, the other three skill areas accounted for a relatively small amount of variance in Evaluate Total, suggesting that Critical Evaluation is a related but unique skill area. Of the four skill areas, Critical Evaluation was more difficult than both Locate and Synthesize but easier than Communicate.

Research question 2: Investigating the Effects of Prior Knowledge, Gender, SES, and Offline Reading Ability on Students' Ability to Critically Evaluate

Two, two-level measurement models were used to address the second research question with students (Level 1) nested within schools (Level 2). Descriptive statistics for the variables are presented in Table 4.1 and bivariate correlations are presented in Table 4.3.

This second research question used a two-level model to investigate the extent to which prior knowledge, gender, SES, and offline reading ability contributed to students' critical evaluation abilities. As with the previous multilevel models, this analysis treated schools as Level 2 and students as Level 1. In this analysis, *Evaluate Total* (this variable was a measure of each student's total Evaluate score, out of four possible points) was treated as the outcome measure, and prior knowledge, gender, SES, and offline reading ability were entered as Level 1 predictors for the second model.

The Unconditional Model

An initial, unconditional model was run first where the variance in subscale scores was partitioned into the two levels as described above. This model had no predictors and provided the necessary variance estimates to calculate the proportion of variance that was within school/between students and between schools (i.e. the intraclass correlation coefficient). This analysis revealed that there was statistically significant variability at both levels. Of the variance in *Evaluate Total*, 90% occurred within schools/classrooms and 9.7% occurred between schools/classrooms. See Table 4.7 for estimates.

The Conditional Model

Given that there was a substantial ICC and significant variance at every level of the model, seven predictors (three student-level and four school-level) were added to the model to account for some of the variance at both levels (between schools and within schools).

First, the prior knowledge, gender, and offline reading variables were group-mean centered by school to create three student-level variables. Given that one interest was in examining the effect of the predictors on the total Evaluate score after controlling for the effects of school, this centering method provided useful results (see Enders & Tofighi, 2007). Group mean centering these variables produced three new, centered variables: *CPK*, *CGENDER*, and *COR*. Second, school mean variables were created for prior knowledge (*sm_PK*), gender (*sm_Gender*), offline reading (*sm_OR*), and school FRPL (*sm_FRPL*) to create four, school-level predictors.

Next, to standardize the scale of the prior knowledge and offline reading variables, z scores were created from both the group-mean centered and the school mean prior knowledge (*ZCPK* and *ZSM_PK*) and offline reading variables (*ZCORM* and *ZSM_ORM*), creating four, new, standardized variables.

The three student-level variables (*ZCPK*, *CGender*, and *ZCORM*) were then added to the model along with the four school-level variables (*ZSM_PK*, *ZSM_Gender*, *ZSM_ORM* and *ZSM_FRPL*), as predictors. This enabled estimates to be provided that showed both the within-school and the between-school contributions for Prior Knowledge, Gender, Offline Reading, and FRPL.

When the three student-level variables and the four school-level variables were added to the model, the -2 restricted log likelihood was reduced from 3946.113 in the null model to

3800.94, showing better model fit. Also, the within-school residual variability in Evaluate Total was reduced by 51.6%, as expected, since three student-level predictors were added to the model, all of which were significant. The residual variability in *Evaluate Total* between schools was reduced by 10.3%, which was expected as well since four school-level variables were added to the model. Given that only one of the four school level variables was significant, it makes sense that the residual variability was not reduced more. Significant variability still remained both within and between schools. See Table 4.7 for estimates.

There were small but significant effects for student-level Prior Knowledge, Gender, and Offline Reading. There was a positive and significant relationship between Prior Knowledge and Evaluate. Thus, for each additional standard deviation increase in Prior Knowledge, Evaluate Total was predicted to increase by .09 points. Similarly, there was a positive and significant relationship between Offline Reading and Evaluate. Thus, for every standard deviation increase in Offline Reading, Evaluate was predicted to increase by .26 points. The analysis also revealed that, on average, girls performed significantly better in Evaluation than did boys by an average of .15 points. See Table 4.7 for estimates.

There were small but significant effects for the school mean for Offline Reading, with a positive and significant correlation between Offline Reading and Evaluation ($r = .351$). For every standard deviation increase in the school mean for Offline Reading, Evaluate was predicted to increase by .21 points. However, the school mean variables for Prior Knowledge, Gender, and FRPL were not significant. See Table 4.7 for estimates.

For this analysis, the standardized and unstandardized coefficients were nearly identical. This was because the standard deviations of the outcome variables were nearly equal to 1.

Table 4.7

Fixed Effects Estimates (Top) and Covariance Parameters (Bottom) for Models of the Predictors of the Evaluation Skill Area

| Parameter | Model 1 (Unconditional Model) | Model 2 (Conditional Model) |
|-----------------------------------|-------------------------------|-----------------------------|
| Fixed effects | | |
| Intercept | 1.48 (.06)* | 1.78 (.27)* |
| <i>Level 1 – Student-specific</i> | | |
| Prior Knowledge (<i>St.</i>) | | .09 (.02)* |
| Gender | | -.15 (.05)* |
| Offline Reading (<i>St.</i>) | | .26 (.02)* |
| <i>Level 2 – School means</i> | | |
| Prior Knowledge (<i>St.</i>) | | .09 (.06) ^{NS} |
| Gender | | -.75 (.49) ^{NS} |
| Offline Reading (<i>St.</i>) | | .21 (.05)* |
| Socioeconomic Status | | .00 (.00) ^{NS} |
| Random parameters | | |
| Intercept | .10 (.03)* | .05 (.02)* |
| Residual | .88 (.03)* | .79 (.03)* |
| -2 *log likelihood | 3946.11 | 3800.94 |

Note. *St.* is “standardized.” *NS* is not significant.

Note: Results are based on data from 1,434 students distributed across 40 classroom sites.

Standard errors are in parentheses. A Bonferroni correction was used to control for Type I error at the .05 level. * $p < .017$ after the correction for the unconditional model and $p < .005$ for the conditional model. *NS* is not significant.

Summary of the Results for Research Question 2

The second research question used a two-level multilevel model to investigate the extent to which four predictors, which included prior knowledge, gender, SES, and offline reading ability, contributed to students' critical evaluation abilities. Students (Level 1) were nested within schools (Level 2), as with the previous analysis. Evaluate Total was treated as the dependent variable and the four predictors as the independent variables entered at Level 1.

An initial, unconditional model was run with no predictors, which provided the necessary variance estimates to calculate the proportion of variance that was within school/between students and between schools (i.e. the ICC). This unconditional model revealed that of the variance in Evaluate Total, 90% occurred within schools/classrooms and 9.7% occurred between schools/classrooms.

A second, conditional model was then run with seven predictors that included three student-level predictors (prior knowledge, gender, and offline reading) as well as four school-level predictors (the school means for prior knowledge, gender, offline reading, and SES). The three student-level predictors were group-mean centered and the prior knowledge and offline reading variables were standardized for both the student-level level and school-level predictors.

The conditional model revealed a reduction in -2 log likelihood from the first model of 145.173, indicating better model fit. In this model, the within-school residual variability in Evaluate Total was reduced by 51.6%, as expected, since three student-level predictors were added to the model, all of which were significant. The residual variability in *Evaluate Total* between schools was reduced by 10.3%, which was expected as well since four school-level variables were added to the model. However, significant variability still remained both within and between schools. See Table 4.7 for estimates.

The conditional model also revealed that there were small but significant effects for student-level Prior Knowledge, Gender, and Offline Reading. There was a positive and significant relationship between Prior Knowledge and Evaluate, and Offline Reading and Evaluate. Girls performed significantly better than boys. For the school mean effects, there were small but significant and positive effects for Offline Reading.

Evaluating the Loss of Data

As noted previously, some students were not included in the primary analysis because they did not have complete data. There were 1,769 total ORCA participants. Of these, 164 had no ORCA-Virtual data, and 146 had only partial ORCA-Virtual data. An additional 25 students had no Offline Reading Measure data or incomplete Offline Reading Measure data. This resulted in 1,434 students with complete ORCA-Virtual data and complete Offline Reading Measure data and were the participants used in the present study. To evaluate the impact of this data loss, two secondary sets of analyses were conducted.

The First Set of Analyses

For the first set of analyses, students who had no ORCA-Virtual data but who had complete ORCA-MC data were compared to those students who had complete ORCA-Virtual (as well as complete ORCA-MC) data to determine whether there were differences between these two groups of students. These two groups of students were compared, using five independent samples t-tests, on the following variables: Prior Knowledge, Gender, Offline Reading, FRPL, and Total Multiple Choice score.

Table 4.8

Comparing Students With No ORCA-Virtual Data to Those with Complete ORCA-Virtual Data

| | Students with No ORCA-Virtual Data But Complete ORCA-MC Data | | | Students with Complete ORCA-Virtual and Complete ORCA-MC Data | | | <i>t</i> -value |
|-----------------|--|----------|-----------|---|----------|-----------|-----------------|
| | <i>N</i> | <i>M</i> | <i>SD</i> | <i>N</i> | <i>M</i> | <i>SD</i> | |
| Prior Knowledge | 163 | 4.79 | 1.77 | 1,394 | 4.65 | 1.73 | .929 |
| Gender | 164 | 1.48 | .50 | 1,396 | 1.49 | .50 | -.278 |
| Offline Reading | 163 | 9.40 | 3.16 | 1,435 | 9.25 | 3.87 | .459 |
| FRPL | 164 | 30.01 | 23.80 | 1,459 | 39.10 | 23.34 | -4.69* |
| Total MC Score | 164 | 6.42 | 38.23 | 1,459 | 5.90 | 23.50 | .267 |

Note. *M* = mean; *SD* = standard deviation. A Bonferroni correction was used to control for Type I error at the .05 level. * $p < .05$.

There were no significant differences on any of these variables except for FRPL (see Table 15). For Prior Knowledge (for students with no ORCA-Virtual score, $M = 4.79$; $SD = 1.77$; for students with a complete ORCA-Virtual score, $M = 4.65$; $SD = 1.73$), $t(1,555) = .929$, $p = .35$, two-tailed. For Gender (for students with no ORCA-Virtual score, $M = 1.48$; $SD = .50$; for students with a complete ORCA-Virtual score, $M = 1.49$; $SD = .50$), $t(1,558) = -.278$, $p = .78$, two-tailed. For Offline Reading (for students with no ORCA-Virtual score, $M = 9.40$; $SD = 3.16$; for students with a complete ORCA-Virtual score, $M = 9.25$; $SD = 3.87$), $t(1,596) = .459$, $p = .65$, two-tailed. For FRPL (for students with no ORCA-Virtual score, $M = 30.01$; $SD = 23.80$; for students with a complete ORCA-Virtual score, $M = 39.10$; $SD = 23.34$), $t(1,621) = -4.69$, $p = .00$, two-tailed. For total ORCA-Multiple Choice score (for students with no ORCA-Virtual

score, $M = 6.42$; $SD = 38.23$; for students with a complete ORCA-Virtual score, $M = 5.90$; $SD = 23.50$), $t(1,621) = .267$, $p = .79$, two-tailed. See Table 4.8.

The Second Set of Analyses

For the second set of analyses, students who had partial ORCA-Virtual data were compared to those students who had complete ORCA-Virtual data. These two groups of students were compared, using five independent samples t-tests, on the following variables: Prior Knowledge, Gender, Offline Reading, FRPL, and Total Locate score. There were no significant differences on any of these variables (see Table 16). For Prior Knowledge (for students with a partial ORCA-Virtual score, $M = 4.47$; $SD = 1.74$; for students with a complete ORCA-Virtual score, $M = 4.73$; $SD = 1.63$), $t(1,603) = -1.79$, $p = .07$, two-tailed. For Gender (for students with a partial ORCA-Virtual score, $M = 1.51$; $SD = .50$; for students with a complete ORCA-Virtual score, $M = 1.49$; $SD = .50$), $t(1,603) = .323$, $p = .75$, two-tailed. For Offline Reading (for students with a partial ORCA-Virtual score, $M = 9.46$; $SD = 3.08$; for students with a complete ORCA-Virtual score, $M = 9.25$; $SD = 3.87$), $t(1,574) = .615$, $p = .54$, two-tailed. For FRPL (for students with a partial ORCA-Virtual score, $M = 35.14$; $SD = 26.19$; for students with a complete ORCA-Virtual score, $M = 39.08$; $SD = 23.34$), $t(1,603) = -1.93$, $p = .05$, two-tailed. For total ORCA-Virtual Locate score (for students with a partial ORCA-Virtual score, $M = 1.80$; $SD = 1.29$; for students with a complete ORCA-Virtual score, $M = 1.85$; $SD = 1.23$), $t(1,603) = -.509$, $p = .61$, two-tailed. See Table 4.9.

Summary of data loss results. Of 1,769 ORCA participants, 335 were missing some of the data needed for the present study, resulting in 1,434 participants used in the present study. Two sets of analyses were conducted to evaluate the loss of data. The first set examined the impact of not including in the primary analyses students who had no ORCA-Virtual data and the

second set examined the impact of not including in the primary analyses students with only partial ORCA-Virtual data. These analyses compared students with missing data to those with complete data to determine if there were significant differences between these two groups that might impact the research findings.

Table 4.9

Comparing Students with Partial ORCA-Virtual Data to Those with Complete ORCA-Virtual Data

| | Students with Partial ORCA-Virtual Data But Complete ORCA-MC Data (<i>N</i> = 146) | | Students with Complete ORCA-Virtual and Complete ORCA-MC Data (<i>N</i> = 1,459) | | |
|--------------------|--|-----------|--|-----------|-----------------|
| | <i>M</i> | <i>SD</i> | <i>M</i> | <i>SD</i> | <i>t</i> -value |
| Prior Knowledge | 4.47 | 1.74 | 4.73 | 1.63 | -1.79 |
| Gender | 1.51 | .50 | 1.49 | .50 | .323 |
| Offline Reading | 9.46 | 3.08 | 9.25 | 3.87 | .54 |
| FRPL | 35.14 | 26.19 | 39.08 | 23.34 | -1.93 |
| Total Locate Score | 1.80 | 1.29 | 1.85 | 1.23 | -.509 |

Note. *M* = mean; *SD* = standard deviation. A Bonferroni correction was used to control for Type I error at the .05 level. *p* > .05 for all variables after a Bonferroni correction.

Each set of analyses included five independent samples *t*-tests that compared students on the following variables: For analysis set 1, prior knowledge, gender, offline reading, school average FRPL, and Total ORCA-MC score (out of 16 points); for set 2, prior knowledge, gender, offline reading, school average FRPL, and ORCA-Virtual total Locate score (out of 4 points).

For the first set of analyses, students who had no ORCA-Virtual data but who had complete ORCA-MC data were compared to those students who had complete ORCA-Virtual data (as well as complete ORCA-MC data). For the second set of analyses, students who had partial ORCA-Virtual data were compared to those students who had complete ORCA-Virtual data. There were no significant differences on any of these variables (see Tables 4.8 and 4.9). Given that there were no significant differences on any of these variables, the researcher proceeded with the primary analyses using only those participants who had complete ORCA-Virtual data as well as complete ORM data.

Chapter Summary

Research question 1. Research Question 1 asked the following question:

What is the nature of students' ability to critically evaluate online information in relation to three other skill areas also required during online reading in science?

Research Question 1 investigated the extent to which students' performance on three different online research and comprehension skill areas in the ORCA-II Virtual (Locate, Synthesize, and Communicate) differed from that of a fourth skill area in the same assessment (Critical Evaluation). The investigation of Research Question 1 used two different sets of analyses to bring greater breadth and perspective to the investigation than one type of analysis alone might have done. Together, they investigated both the uniqueness and difficulty of the Critical Evaluation skill area in the ORCA-II Virtual. These analyses included a set of four regression models, which focused on the uniqueness of the Critical Evaluation skill area in contrast to the other three skill areas. These analyses also included a set of three, two-level

multilevel models, which focused on the difficulty of the Critical Evaluation skill area in comparison to the other three skill areas.

The results of the first set of analyses were all significant and revealed that Locate accounted for 5.2% of the variance in Evaluate Total, Synthesize Total accounted for 12.3% of the variance, and Communicate accounted for 5.9%. The results also showed that together, Locate, Synthesize, and Communicate accounted for 16.2% of the variance in Evaluate Total.

The results for the second set of analyses demonstrated that, of the variance in the mean difference between each skill area total and Evaluate Total, 97.7 was within schools for Locate and 97% within schools for Communicate, both of which were significant. The within school variance was not significant for Synthesize. The between school variance was not significant for any of the analyses. These analyses also showed that students performed significantly better on both Locate and Synthesize compared to Evaluate but that they performed more poorly on Communicate.

Research question 2. Research Question 2 asked the following question:

During online reading in science, to what extent do prior knowledge, gender, SES, and offline reading ability contribute to students' ability to critically evaluate the credibility of online source information?

Thus, Research Question 2 investigated the extent to which four variables with indications for individual differences (prior knowledge, gender, SES, and offline reading ability) contributed to students' ability to critically evaluate the credibility of online source information in the ORCA-II Virtual. The investigation of Research Question 2 used a single, two-level multilevel model to conduct the analysis for this investigation. In this model, as with the prior multilevel model, students (Level 1) were nested within

schools (Level 2). Evaluate Total was treated as the outcome variable, with three of the individual difference variables (prior knowledge, gender, and offline reading) entered into the model as predictors at Level 1 and the school means for all four of the individual difference variables (prior knowledge, gender, SES, and offline reading) entered into the model as predictors at Level 2.

An initial, unconditional model with no predictors revealed the majority of the variance in Evaluate Total (90%) occurred within schools, with 9.7% occurring between schools. A second, conditional model that included seven predictors (three student level variables that were prior knowledge, gender, and offline reading as well as four school-level variables that included the school means for prior knowledge, gender, offline reading, and SES) revealed that this conditional model was a better fit than the unconditional model. There was a reduction in the -2 log likelihood from the first model of 145.173. Additionally, the within-school residual variability in Evaluate Total was reduced by 51.6%, as expected, since three student-level predictors were added to the model, all of which were significant. The residual variability in *Evaluate Total* between schools was reduced by 10.3%, which was expected as well since four school-level variables were added to the model. However, significant variability still remained both within and between schools. See Table 4.6 for estimates.

The conditional model also revealed that there were small but significant effects for student-level Prior Knowledge, Gender, and Offline Reading. There was a positive and significant relationship between Prior Knowledge and Evaluate, and Offline Reading and Evaluate. Girls performed significantly better than boys. For the school mean effects, there were small but significant and positive effects for Offline Reading.

Evaluating Data Loss. Two sets of analyses were conducted to examine the impact of data loss on the dataset used for the present study. Both sets of analyses compared students with certain data to those without the same data. Both sets of analyses revealed that there were no significant differences on any of the variables examined between students with data and those without data.

CHAPTER V

DISCUSSION

Introduction

This study sought to investigate seventh grade students' ability to evaluate the credibility of online information in science. Specifically, this study explored the extent to which students' performance on a set of four critical evaluation items during online reading in science differed from their performance on four-item sets of three other skill areas required during online reading in science, including locating, synthesizing, and communicating. This study also explored the extent to which four individual difference variables that included prior domain knowledge, gender, socioeconomic status, and offline reading ability, influenced their performance on the four critical evaluation items. The findings from this study are briefly summarized in the following sections, and the implications of these findings for theory, research, assessment, and instruction are discussed. Considering these implications may help to better prepare students at a younger age for engaging with science in a digital information age.

Research question 1: Exploring the Nature of Students' Ability to Critically Evaluate in Relation to Students' Ability to Locate, Synthesize, and Communicate During Online Reading in Science

Critical Evaluation is a Unique and Difficult Skill Area for Students in Online Reading

The first research question investigated the extent to which critical evaluation during online reading in science differed from three other skill areas required during online reading in science that included locating, synthesizing, and communicating. The first research question did so by investigating the shared variance between critical evaluation and each of the other three skill areas as well as the extent to which students' performance on critical evaluation differed

from their performance on the other three skill areas. The present analysis revealed that critical evaluation was a unique and difficult online reading skill area for students. This finding is consistent with some prior research (Coiro et al., 2015; Forzani & Burlingame, 2012; Grimes & Boening, 2001; Goldman et al., 2012; Halverson, Siegel, & Freyermuth, 2010; McVerry, 2013; Walraven, Brand-Gruwel, & Boshuizen, 2008). The present study, however, examined a larger sample size compared to prior studies, used a performance-based measure, and used a quantitative approach.

An analysis of shared variance showed that each of the skill areas of Locate, Synthesize, and Communicate appeared to contribute a relatively small amount of variance to the Evaluate skill area (5.2%, 12.3% and 5.9% respectively). Given that Cronbach's alpha for each skill area revealed only moderate reliabilities (.56 for Locate, .66 for Synthesize, .49 for Communicate and .44 for Evaluate), however, we would expect a relatively low amount of shared variance. Therefore, these adjusted R Square values should be viewed within the context of these reliabilities. Small but positive and significant correlations between Locate and Evaluate ($r = .23, p < .000$), Synthesize and Evaluate ($r = .35, p < .000$) and Communicate and Evaluate ($r = .245, p < .000$) support these R squared values. The relatively low amount of shared variance between Evaluate and each of the other three skill areas supports the notion that each of these three skill areas is measuring a unique construct apart from Evaluation.

Descriptive statistics for students' performance in the Critical Evaluation skill area showed that this skill area was markedly difficult for students. While 83% of students were able to identify the author of a webpage, the majority of students could do little else besides this basic skill in the Evaluate area. Only 31% could evaluate the author's point of view, and only 23% could evaluate the author's level of expertise. For the product score point, which involved the

three skills in the process score points, only 15% could actually evaluate the overall reliability of a website. Without this skill set, it is likely that students may use information during online searches in science that is inaccurate, leading to the development of misconceptions (Wiley et al., 2009).

The three multilevel models examining the mean differences of each skill area compared to Evaluate further support the difficulty of the critical evaluation skill area by revealing that there was a significant mean difference between each of Locate and Evaluate, Synthesize and Evaluate, and Communicate and Evaluate. Students performed best on Locate, followed by Synthesize, Evaluate, and then Communicate. These findings support past research with high school and college students (e.g., Goldman et al., 2012; Kiili et al., 2008; Zhang & Duke, 2008) as well as with younger adolescents (e.g. Barzilai & Zohar, 2012; McVerry, 2013; Walraven, Brand-Gruwel, & Goshuizen, 2009) suggesting that online critical evaluation is a difficult skill area for students. However, the present study extends these prior findings about the difficulty of critical evaluation by investigating the critical evaluation skill area in comparison to three other online reading skill areas, those of locating, synthesizing, and communicating information and by doing so in a performance-based environment, and within a simulated, science-specific Internet context, which other studies have not done.

Exploring the Reasons for the Difficulty of Critical Evaluation in the ORCAs

One reason that critical evaluation was difficult for students in the present study may be that it is a higher-level skill that requires proficiency with many other lower-level skills (see Anderson, et al., 2001, for example). If critical evaluation requires students to use other skills, such as locating, synthesizing, and communicating, then it would make sense that these other skills would have been easier for students. In the present study, the four critical evaluation items

did not require high degrees of locating skills, as the text students were instructed to evaluate was provided to them via a link. However, the critical evaluation items did require students to engage in communication and synthesis skills. First, students were required to access the critical evaluation items via a chat message interface in which another avatar student provided the items, so students did use communication skills to a small degree. Second, students may have needed some ability to synthesize information across the different webpages in the task in order to compare what they had learned on the different webpages as well as to compare what they had already learned to their prior knowledge, a strategy known in disciplinary literacy as corroboration. This would have allowed students to evaluate the webpage provided for the critical evaluation task based on the extent to which it fit with other information. However, this may have been true for the other skill areas as well. The locating skill area, for example, required students to evaluate as well as locate, as students had to determine which webpages they should navigate to. Interestingly, the communication skill area required students to synthesize, evaluate, locate, and communicate, which may be one reason why it was the most difficult of the four skill areas. In fact, all four skill areas required a mixture of different lower- and higher-level sub-skills.

It is also possible that students struggled with the critical evaluation items because these items required new, online reading skills with which students were less skilled. Indeed, some research shows that online reading may require new and different skills compared to offline reading (Afflerbach & Cho, 2009; Coiro & Dobler, 2007; Leu et al., 2013). It may be that current instruction and assessment are only just beginning to emphasize these kinds of skills (or are not teaching them at all), particularly in science, and so students are not yet especially skilled at

them. Students may have been less proficient with these kinds of skills because these skills are taught less often or less well than traditional, print-based reading skills.

In offline science, critically evaluating sources and information is an important skill (Halverson et al., 2010). This may become even more important in online science. It may be that, particularly in comparison with other disciplines, students struggle with evaluating the credibility of scientific information, a problem that may be compounded by the lack of information stability and reliability on the Internet. Critical evaluation may differ somewhat in an online science environment in ways that are specific to this context. For example, in the present study, students needed to navigate to an “About the Author” page in each task in order to learn more about the qualifications of the author for writing a piece of information and evaluate the credibility of the author (the second critical evaluation score point). Once on this page, students may have needed further knowledge about science to evaluate the author’s qualifications (see, for example, Figure 5.1; See Appendix C for all four “About the Author” pages in the ORCAs). Similarly, students may have needed knowledge about the credibility of online science publishers to further evaluate the source of information, or may have needed to know how to access and evaluate the evidence an author used to support an argument.

These specialized online science skills may also be more difficult than those required by other disciplines. For example, in order to evaluate information quality in a scientific text, a reader needs to be able to understand the author’s argument. This requires students not only to understand conceptual knowledge about science, but also to understand the process of argumentation in science, and thus, what constitutes a quality argument.

Additionally, some research suggests that readers might suspend their critical stance when reading an unfamiliar text (see, for example, Shanahan et al., 2011). It may be that this is

precisely what some of the more unskilled and unknowledgeable students were doing as they read the texts in the present study. Students may have needed to conserve their resources and focus all of their attention on understanding rather than on evaluating the extent to which information is credible. If this is the case, then it is important that we not only teach students not conceptual knowledge about science, but also help them to understand how to evaluate scientific arguments even when they are unfamiliar with the topic.

Figure 5.1. The “About the Author” Page for the Video Games and Eye Health Task

Dr. Troy L. Bedinghaus

http://www.About.com/L3-23_filename.html

Study: Video games | Video Games Good for | Study: Playing Video | Dr. Troy L. Bedinghaus | Google | Google | >>

Advertisement Sign Up! About.com Cats Newsletter SIGN UP NOW

About.com Vision

Vision Healthy Eyes Eye Problems Vision Correction

Share Print

Troy Bedinghaus, O.D.
About.com Guide
Email Me | My Blog | My Forum

Free Vision Newsletter!
Enter email address Sign Up
Discuss in my Forum

Advertisement

Dr. Troy L. Bedinghaus is a board-certified optometric physician. He owns and operates Lakewood Family Eye Care, a private eye care facility in Lakewood Ranch, Florida.

Experience:

Dr. Bedinghaus has practiced in many clinical settings including a large, multi-specialty ophthalmology practice, commercial opticals, primary medical rural health clinics and private optometric practices. He is a member of the American Optometric Association and the Florida Optometric Association. He also serves as president of the Manasota Optometric Society.

Education:

Dr. Bedinghaus graduated from Texas A&M University with a bachelor's degree in biology. He then attended the University of Houston College of Optometry, where he earned his doctorate degree in optometry. He completed externships at St. Luke's Cataract and Laser Institute and Manatee/Sarasota Eye Clinic and Laser Center, both in Florida.

From Troy Bedinghaus, O.D.:

With my strong passion for optometry, I will strive to provide the public with valuable information and resources for total eye health. I believe that eye care is an important part of general health, and keeping your eyes healthy is a lifetime commitment.

Sponsored Links

[Avon Medical Group](#)
Quality Healthcare for 50 Years Walk-In Open 7 Days a Week
www.amcicare.com

[AARP Member Discounts](#)
Exclusive AARP member discounts on vision care and eye wear. Look here
www.aarphealthcare.com

[LASIK for Astigmatism](#)
So Cal Experts. Since 1986. LASIK 0 Down 0% Financing Here!
www.LaserEyeCenter.com

Advertisement

HOT DANG
SAVE UP TO 90% ON LOCAL EATS

See Today's Deal

Groupon

www.Groupon.com Ads by Google

A third reason for students' performance on the critical evaluation skill area in the present study may have been related to the way in which this skill area was assessed. Some prior research (Forzani & Burlingame, 2012) has shown that Evaluate on a prior version of the ORCA was the most difficult online reading skill, even compared to Communicate. In the present study, however, Communicate was more difficult than Evaluate. One reason for this may be that this prior study used data from Year 3 of the ORCA Project, while the present study used data from Year 4 of the project. The fourth Communicate score point was revised between these two years, with the fourth Year 4 score point requiring students to include their sources in their email message that communicated their findings. The purpose of this was to better align the score points with what students would be required to do in the Common Core State Standards (CCSS, 2010). As the results show, this made Communicate more difficult than Evaluate for students taking the Year 4 assessment, which was not the case for students taking the Year 3 assessment.

This highlights an important point about future assessments of online critical evaluation. One aim of future assessments of online critical evaluation should be to further develop the critical evaluation scale with additional items that help further discriminate the component skills involved in this skill area. The ORCAs are a relatively new set of assessments that have laid the groundwork in a significant way for assessing online reading skills, especially in science. As further online reading assessments are developed, it will be important for test developers to build off of this initial work by paying close attention to the properties of each online reading skill area scale. One such assessment that is modeled in part on the ORCAs is the ePIRLS Online Reading assessment (Mullis & Martin, 2015). While this assessment encompasses many ORCA skills, it does not separate the skills into online skill areas but rather places them in the context of offline skill areas, which may not be isomorphic with online skill areas (Leu et al., 2007). Critically

evaluating information in online environments appears to involve somewhat different skills and strategies than doing so in offline environments. Given that online and offline reading skills may not overlap well, when the results for this assessment are published, it will be difficult to determine how students performed in each skill area and on which skill area(s) educators should focus their attention. By further defining each online reading skill area, future assessments of online reading comprehension can refine the measurement of these important skills and provide more discrete information for educators to use in instruction. Moreover, the ePIRLS Online Reading assessment only includes a very small percentage of items on critical evaluation (Mullis & Martin, 2015). Therefore, the results of this assessment will not provide detailed information about how well students perform in the component areas of critical evaluation.

One assessment that does focus entirely on online critical evaluation is the COIL (McVerry, 2013; O’Byrne, 2013). Unlike the ePIRLS assessment, the COIL does include many component skills of online critical evaluation. However, critically evaluating information in science in online environments may require different skills and strategies than critically evaluating information in other subject areas. While both the ePIRLS Online Reading assessment and the COIL assessment measure general online critical evaluation skills, they do not measure discipline-specific skills.

Assessments of scientific literacy should be developed specifically for science and measured within the context of other science skills (See, for example, Lee et al., 2012). This includes assessments of online critical evaluation in science. Such assessments would provide educators with methods of measuring students’ skills in online critical evaluation for science within its own discipline. For example, in addition to asking students to examine author expertise in the process of determining overall informational credibility, students also could be asked

specifically to focus on evaluating the quality of the author's argument, one aspect of argumentation (Halverson et al., 2010) and an important skill for science (Shanahan et al., 2011).

Currently, this skill is subsumed by the fourth critical evaluation score point in the ORCA, as this is one way students can answer this fourth item in order to obtain credit. However, the critical evaluation scale in the ORCA does not specifically require students to do so, as there are other ways in which a student can evaluate the quality of the information in order to earn credit. Students also can refer to author expertise or publisher trustworthiness, also known as *sourcing* (see Table 6 for the scoring criteria for the Evaluate scale in the ORCA), which is another important element of evaluating the reliability of information in science (*sourcing*) but are not aspects of argumentation, specifically. A student can thus score 4 out of 4 points in the Evaluate scale without necessarily evaluating the quality of the author's argument. Therefore, examining a student's performance on the critical evaluation scale in the ORCA does not necessarily provide information about how well the student engages in online argumentation, specifically. Given that argumentation is such a central aspect of science and of science education (NGSS Lead States, 2013), this would be important for educators to know, and future assessments of online critical evaluation in science should include this as a specific score point. Also, understanding students' strengths and weaknesses in different aspects of online critical evaluation in science related to text, reader, and context would be particularly useful for educators so that instruction can be targeted to meet students' needs.

Currently, major assessments of science (e.g., NAEP, PISA, and TIMSS) do assess both scientific content and scientific literacy, or practices, which includes the evaluation of the validity of information (NAEP; OECD, 2013; Jones, Wheeler, & Centurino, 2013). However, these assessments do not include items relating to evaluating online information. Given the

importance of preparing students for a world in which the Internet is a key context for science information (Horrigan, 2006; Thomm & Bromme, 2016) this is highly problematic. As these assessments are revised in the future, test developers should consider the Internet as a key context in which to assess students. Within this context, test developers could consider including the online evaluation skills in science that are so necessary and important to the field.

An assessment of online evaluation in science would need to contain items that require students to engage with online scientific texts and could evaluate students on their abilities to read and interpret different aspects of these kinds of specialized texts. These aspects might include text features such as clickable technical vocabulary, interactive numerical and visual information (e.g. charts, graphs, images), nominalizations, and lexical density (Fang, 2005; Lemke, 1998; Shanahan et al., 2011).

In addition to measuring students' ability to read and interpret these different aspects of online scientific text, an assessment of this sort might also contain items that evaluate students on the strategies they use to engage with this kind of text. Such strategies to evaluate for online scientific text might include *corroboration* (Shanahan et al., 2011) and *sourcing* (Wineburg, 1991; Shanahan et al., 2011). Finally, assessments might include items that evaluate the ways in which different contexts affect students' learning and understanding. Contexts might include the ways in which specific scientific domains interact with text and reader, or how different research questions influence students' reading abilities.

In order to better understand students' strengths and weaknesses in each area, including the ways in which each skill area both stands on its own and functions in relation to other skill areas, it will be important for assessments of online reading to determine students' abilities in

each area. Only by understanding critical evaluation on its own will we be able to better understand it in relation to other skill areas.

One limitation of the present study was that it did not assess an entire repertoire of online reading skills for science. Rather, the present study focused only on four skills within each of four online reading skill areas. First, within each of these four skill areas, there are likely many more skills students need in order to successfully read and comprehend during online science in reading. Second, the study did not include items that assessed students' ability to define important research problems, a potentially important fifth skill area important for online reading and research (Leu et al., 2013) and for science research.

Regarding the critical evaluation skill area specifically, the present study did not assess the full range of possible critical evaluation skills students might need during online reading in science. The present study did not, for example, assess all of the smaller sub-skills that go into the item that asked students to evaluate the author's expertise. The present study also did not allow students to show their thinking regarding how they went about evaluating an author's argument, which was one way in which students could earn credit for the fourth evaluation score point (evaluating the overall reliability of a given webpage). There were several ways in which students could obtain a score point for the final Evaluation item in the ORCA. Therefore, the results in the present study do not allow us to see why or why not students were able to correctly evaluate a given website. While a similar qualitative study of the Evaluate section of the ORCA (see Coiro et al., 2015) does shed some light on students' responses, even this study does not necessarily allow us to see how students could do specific tasks, such as evaluating the credibility of an author's argument, since there were other ways in which students could get the final Evaluate score point correct.

Thus, future studies, both qualitative and quantitative, are needed to investigate the full repertoire of literacy skills students need for online reading in science, especially for the critical evaluation skill area. This would allow researchers, educators, and assessment developers to better understand the skills students need for doing science. Studies also are needed to investigate the specific critical evaluation skills students need for online reading in science specifically.

For example, studies that investigated students' ability to evaluate the credibility of sources in different disciplinary areas and how this process might differ for these different disciplines, especially for online reading in particular, would be useful. Think aloud studies of expert scientists would allow us to examine the ways in which scientists evaluate online texts. Similarly, think aloud studies of novices (perhaps such as the participants in the present study) would allow us to better understand what students know and are able to do regarding a variety of evaluating skills in science.

Studies such as these would allow for better, more targeted, instruction to help students learn the skills they need in order to read and evaluate texts during online reading in science in the ways in which actual scientists do. Studies such as these would also aid in further research development around how best to teach students critical evaluation skills that they can use even when unfamiliar with scientific content. This may be particularly valuable to teachers and to students. Given that it is not possible to teach students all of the content knowledge they may need in the vast body of scientific content knowledge that exists, it is a much more achievable goal to teach students processes of scientific evaluation that they can use with any content. Future studies should focus on examining these evaluation processes in an online science environment, specifically.

Research question 2: Investigating the Effects of Prior Knowledge, Gender, SES, and Offline Reading Ability on Students' Ability to Critically Evaluate

The second research question investigated the extent to which prior domain knowledge, gender, SES and offline reading ability contributed to students' ability to critically evaluate the credibility of online information during an online research task in science. This study sought to investigate these effects at both the within-school and between-school level to better understand whether the factors affecting the outcomes were attributable to student-level differences or to school-level differences.

Results of the multilevel models for the second research question revealed that there were significant effects at both the within-school and between-school levels for Evaluate, though most of the variance occurred within schools (90%) compared to between schools (9.7%). This suggests that for learning critical evaluation skills, the characteristics of the school a student attends are much less important than the student's individual skills, though they do still play a significant role.

Regarding the predictors specifically, there were small but significant within-school effects for Prior Knowledge, Gender, and Offline Reading and small but significant between-school effects for Offline Reading. There were no significant between-school effects for Prior Knowledge, Gender or FRPL, however.

Prior Knowledge

There were significant within-school effects for domain-specific prior knowledge, though these effects should be viewed within the context of the relatively low reliabilities for the prior knowledge measures. Low reliability values may mean that the measures are not measuring the domain knowledge in a way that accurately reflects the content of each given domain. Even so,

these measures include items relating to the given domain area assessed in the ORCA that followed it (functioning of heart or functioning of eyes). Students' knowledge in these domain areas might then conceivably impact their performance on the domain-specific ORCAs that followed.

Many past studies have found that prior knowledge plays a significant role in offline reading comprehension (Anderson & Pearson, 1984; Kintsch, Patel, & Ericson, 1999; Voss, Fincher-Keifer, Green, Post, 1985). This is because students are able to leverage their prior knowledge as a tool in the process of comprehending new information. As they read, students integrate new information into an existing framework. Theoretically, this is easier and thus results in better comprehension than learning new information without a framework, since the framework acts a scaffold, or support, for understanding. While some have suggested that prior knowledge may be less important in an online environment compared to an offline one (Bilal, 2000; 2001; Coiro, 2011; McVerry, 2013), this may not be true with respect to the online skill area of critical evaluation, specifically. In fact, some have suggested that prior domain knowledge may be especially important for critically evaluating information both in terms of argument (Scharrer, Stadtler, & Bromme, 2014) and in terms of sourcing (Shanahan et al., 2011). Evaluating sourcing becomes particularly important in an online environment since there is such a large amount of information with such varying degrees of quality in an online environment (Goldman et al., 2012).

In the present study, on average, students with greater degrees of domain-specific prior knowledge on a given task were better able to evaluate the extent to which a text was a reliable source of information for the research question. Past research (Coiro, 2011) found that prior knowledge was not a significant factor in students' online reading abilities for high- and average-

ability online readers. The findings from the present study may seem surprising within this context. One possibility for this may be related to the fact that Coiro's research looked at overall online reading comprehension, encompassing the four skill areas of Locate, Evaluate, Synthesize, and Communicate, whereas the present study investigated the effects of prior knowledge on the Evaluate skill area specifically.

There may be important differences in how prior knowledge affects a student's critical evaluation abilities specifically compared to the ways in which it affects a student's overall online reading abilities. First, Coiro (2011) hypothesized that better online readers may be able to gain the knowledge they need to comprehend texts as they read online since they can direct the pathway of their reading, thus making initial prior knowledge less important to their comprehension abilities than for offline texts. However, this may be difficult for students to do when evaluating compared to simply synthesizing information, for example, as there is such a large degree of prior knowledge in many areas that one must bring to bear on a text when evaluating its reliability. These types of prior knowledge might include understanding of an author's credentials, knowledge about the publisher's reliability and the publication date, prior knowledge of the topic area, and knowledge about the structure of reliable texts in science (Bazerman, 1985; Shanahan et al., 2011). A student who scored high on the prior knowledge assessment in the ORCAs may be more likely to have this type of knowledge than would a student who scored low in this area. It may be that as students develop more knowledge about a given domain area, they also develop knowledge about which authors and publishers are credible as well as knowledge about how credible texts are structured in science.

Also, it may have been particularly unlikely for students to conduct side searches given the way in which critical evaluation was assessed in the present study. In the ORCA, the critical

evaluation questions appeared together, as a set, with no other questions or tasks in between them. Therefore, it seems less likely that students would have, on their own, gathered additional domain-specific prior knowledge to use in assessing the reliability of the specific webpage they were required to assess for the critical evaluation tasks.

Second, prior knowledge may be more important for critical evaluation, specifically, than for online reading as a whole. Disciplinary knowledge is required for effective sourcing (Shanahan et al., 2011). Students with greater degrees of prior knowledge at the start of the assessment would have been able to use that disciplinary knowledge when assessing the author's reliability, including credentials and professional experience, as well as when assessing the author's biases and the quality of the information on the page. For instance, students with greater degrees of prior knowledge may have been more familiar with the types of credentials an expert in a given field might have. For example, a student who knows more about eye health might understand that an "ophthalmologist" is an eye doctor who is very knowledgeable about eye health. This would be important knowledge when analyzing the extent to which the author of the critical evaluation page for the Video Games task was an expert on eye health and thus the extent to which this author might be providing accurate and reliable information.

Similarly, students with greater degrees of domain-specific knowledge prior at the start of the assessment may have been able to use this information to assess the quality of the information on the critical evaluation webpage. Students with greater degrees of prior knowledge may have been more likely to understand specialized vocabulary words and concepts related to the life science area for a given research task, important aspects of scientific reading (Shanahan et al., 2012). For example, in the Video Games and Eyesight task (see Figure 5.1), students needed to understand specialized vocabulary concepts, including "computer vision syndrome"

and “focusing” in order to fully understand the information provided and then evaluate the reliability of that information. Understanding the concept of focusing in the context of eye health and vision, for example, would help a student evaluate the internal logic, and thus the reliability, of the scientific explanation provided as to how eyes focus differently on a video screen than on a flat surface such as a piece of paper (see Figure 2.9).

It may be that critical evaluation, especially in science, requires a large degree of domain-specific prior knowledge because readers must apply this knowledge as a starting point against which to compare new information they encounter. This may be more difficult than simply using prior knowledge to understand information provided since a student has to actually apply a prior understanding to new information and make a decision about the accuracy of the new information, a step not required when merely synthesizing new information with old.

In his 1985 study of physicists, Bazerman found that the prior knowledge that the physicists brought to bear on the scientific texts they read helped them determine what information to pay attention to. The physicists paid greater attention to new information and were more critical when reading work related to their own area. Having prior knowledge, in this case, as the experts likely had greater prior knowledge in their own area than in other areas, allowed the physicists to take a more critical stance towards the information. Shanahan et al., (2011) found a similar pattern, with expert chemists attempting to corroborate what they read with their existing knowledge of a topic area, thus allowing them to evaluate the reliability of a scientific text based on their prior knowledge.

There were no significant effects for the school mean for prior knowledge. Thus, being surrounded by peers with greater degrees of prior knowledge did not significantly impact a student’s Evaluate score. This is contrary to findings around peer effects for general academic

achievement, which show that students typically benefit academically from being surrounded by high-ability peers (Coleman et al., 1966; Hoxby & Weingarth, 2007; Vardardottir, 2013). These effects may be due to the fact that a greater proportion of high-ability peers results in higher quality teaching practices, inter-student relationships, teacher-student relationships, and fewer classroom disruptions (Lavy, Paserman, & Schlosser, 2008). However, in the case of the present study, having high-ability peers did not appear to result in higher achievement in critical evaluation. It may be that there is not a direct correlation between achievement and prior knowledge in these particular domain areas, especially if these areas (heart and eyes) had not been covered in the classroom at the time of the assessment.

Gender

There were small but significant within-school, but not between-school, effects for gender. On average, girls performed .15 points (out of 4 points) above boys on Evaluate. Despite past research showing gender gaps in science, with boys often outperforming girls (Katz et al., 2006), girls still performed better on Evaluate than did boys. Given the significant effects for offline reading at the between-student level and the large gender gap in offline reading favoring girls (Logan & Johnston, 2010), it may be that this gap carried over into online reading as well. This finding from the present study corroborates evidence from the 2012 PISA study of digital reading (OECD, 2010), showing a gender gap, favoring girls, among 15-year-olds in 19 nations. This gap was smaller for online reading than for offline reading (Borgonova, 2016).

One reason that the gender gap in online Evaluation was not larger may be that boys' skills and attitudes in other areas compared to girls helped mitigate the gender effects we typically see for offline reading. Boys' greater skills in science (Katz et al., 2006), informational reading (Mullis et al., 2012), preferences for online reading (Liu & Huang, 2008), and more

positive attitudes about the Internet in general (Jackson, Ervin, Gardner, & Schmitt, 2001; Schumacher & Morahan-Martin, 2001) compared to girls may have helped boys. It is possible that boys' advantages in these other areas acted as a "buffer" against the gender effects we often see for offline reading, mediating boys' online science achievement. This is one interesting area that should be explored in much greater depth.

Additionally, given that girls appear to have a particular advantage over boys with constructed response items (Schwabe & McElvany, 2014), this finding is especially interesting. All four of the Evaluate items required constructed responses. It is possible, then, that girls had an item format advantage over boys in the present study. Despite this advantage, the gender gap was relatively small.

While newer studies show no differences between boys and girls in attitudes towards the Internet (Kim et al., 2007; Koohang & Durante, 2003), these studies did not specifically examine online reading and critical evaluation, especially in science. If it is the case that an online environment provides boys with a context more conducive to reading success than does an offline context, this is both an advantage and a disadvantage for boys. On the one hand, we are still seeing a gender gap in an important online reading skill area. This means that boys' online critical evaluation skills need more attention. On the other hand, educators may be able to leverage boys' possibly stronger skills in and preferences for sciences and online contexts to help close the offline reading gap, a gap that has been a persistent problem in literacy education and achievement for boys for several decades (Loveless, 2015). In the process, this may help to close the online reading gender gap as well.

That there were no significant school effects for gender is interesting and highly promising given the negative peer effects that are sometimes seen for gender on both boys and

girls in academic achievement (Caldas & Bankston, 1997; Lavy & Schlosser, 2011; Zimmer & Toma, 2000). Hoxby (2000), for example, found that classrooms with higher percentages of girls correlated with higher test scores for both boys and girls. Some research has shown a difference in science achievement between middle school girls in single-gender middle science classrooms and middle school girls in mixed-gender science classrooms, with the girls from the single-gender classrooms outperforming those from the mixed-gender classrooms (Brooks, 2011).

For evaluating online information in science, the content, skills, and context may “level the playing field” for gender. While girls may be more skilled than boys in offline reading (Logan & Johnston, 2010) and boys more skilled in science (Katz et al., 2006), the Internet may be one context in which both genders feel familiar and comfortable. Perhaps boys bring greater scientific abilities to online reading and research and girls’ greater reading abilities, making students of both genders relatively confident in an online evaluation task.

Offline Reading

As was anticipated, there were small but positive and significant between-student and between-school effects for Offline Reading.

Within-school effects for offline reading. Students who had stronger offline reading abilities were more likely to have stronger critical evaluation abilities as well, as we have seen in past studies (Coiro, 2011; Leu et al., 2012). However, also as we have seen in past studies of online reading, the contribution of offline reading skills to online reading skills, namely, online critical evaluation, was significant but not especially large, supporting both the idea that online reading and offline reading share something in common (Coiro, 2011) but also that they are not isomorphic (Leu et al., 2007).

Given that offline reading contributed to some of the variance in Evaluate scores, it is important to pay attention to students' offline reading skills when teaching critical evaluation. Some critical evaluation abilities may carry over into online reading, despite the varying contexts. For example, in the ORCAs, students had to evaluate the overall accuracy and reliability of the information presented in a given text. This skill may relate to the structure and content of the text itself rather than to the context of that text, meaning that the skill would be the same regardless of format.

While critical evaluation may be a more important skill in an online environment, the fundamental nature and characteristics of this skill may not be all that different. First, skilled online critical evaluation requires a critical stance – the ability to comprehend information and then to judge the reliability of that information rather than to automatically accept it as true. If students fail to take this stance, it will not matter whether or not they have the skills to evaluate the reliability of information since they will not initiate the evaluation process in the first place. This critical stance is important regardless of offline or online environment.

Second, once students have taken a critical stance, they must evaluate the author's expertise. While obtaining the information in order to do so (by clicking on a link for the author biography page) may require a somewhat different process online or offline, the process of evaluating the author may be somewhat the same. In both contexts, students need to judge the author's expertise using the author's credentials and experience. However, students may also need to have online- and discipline-specific knowledge, such as knowledge about the credibility of different online science publishers.

Despite many of the similarities of evaluating the reliability of information online and offline, an online environment may present new and even greater challenges for critically

evaluating information than an offline environment, especially in the field of science. Some aspects of the critical evaluation task in the ORCAs are likely related to new, online science-specific skills. For example, to evaluate an author's expertise in the ORCAs, students needed to be able to navigate to a secondary webpage that provided background information on the author. This may be different from the way a student might do this with an offline text, since students need to know how to find the author biography page online. Additionally, online, students must contend with advertisements and hyperlinks, which may distract them from the task at hand.

Similarly, corroborating sources may be done offline, but is likely to be done more often online, since it is a much faster, easier process. Students easily can, in a matter of minutes, conduct a side search of information while they are researching a given topic. This is more difficult and takes more time offline, where a reader must spend time locating additional books, which may be at various libraries.

Moreover, while some of online publishers will be similarly known offline and online (e.g., The New York Times), in an online context, students may need prior knowledge about certain common online publishers or organizations that either do not exist offline (e.g., About.com) or that have a more commonly understood online presence for non-expert audiences (e.g., MayoClinic.com).

Between-school effects for offline reading. In addition to the within-school effect for offline reading, there was also a significant between-school effect for offline reading ability. Students from schools with a higher average offline reading score performed better on Evaluate than did students from schools with a lower average offline reading score. One interpretation of this finding is that, as with prior knowledge, offline reading skills are a necessary prerequisite to online reading. In schools where students had, on average, high degrees of prior knowledge,

teachers would therefore have had a more advanced “starting point” when teaching online reading skills and, specifically, online critical evaluation skills. Teachers would therefore have been able to devote more time and effort to teaching critical evaluation skills in schools where students already had good offline reading skills.

Socioeconomic Status

Interestingly, FRPL, a proxy measure for school-level SES, was not a significant factor contributing to students’ ability to evaluate the reliability of online sources. This was a somewhat surprising finding given that prior studies of both offline reading (see Bailey & Dynarski, 2011 and Reardon, 2011, for example) and online reading (see Leu et al., 2012) have found a large achievement gap between students from higher- and lower-income backgrounds. This phenomenon may have occurred due to the little variance in critical evaluation abilities in general since scores were relatively low for all students.

Some researchers have hypothesized (Leu et al., 2012; Leu, Kiili, & Forzani, 2015) that wealthier students’ greater access to and experience with computers and the Internet is one likely reason for a significant online reading achievement gap related to wealth, above and beyond the offline reading gap. The 2011 PISA assessment of digital reading (OECD, 2011) found a significant difference in scores between students who did and did not use a computer at home. These findings suggest that out-of-school experiences with a computer and not just in-school experiences may be important for helping students to develop online reading skills. This implies that through trial and error experience, students are able to teach themselves skills and strategies that can be applied to online reading and research.

Critical evaluation skills may be more difficult, however, to gain through exploration alone since critically evaluating credibility requires more than familiarity with the online

information space. Thus, with online critical evaluation, it may be that out-of-school Internet experiences are less important than they are with digital reading in general. It may be that critical evaluation requires a more knowledgeable teacher. This may be because critical evaluation requires a critical stance, something one is unlikely to learn on one's own. These habits of mind may be more readily learned from other people.

Another possible reason that socioeconomic status did not contribute to students' ability to critically evaluate in the present study may be that the presence of laptops in the state that had a one-to-one laptop initiative acted as a mediating variable. The one-to-one laptop state happened to be a more economically disadvantaged state than the non- one-to-one laptop state. Potentially better online reading skills due to presumed greater frequency of instruction using laptops (and likely using the Internet) may have lessened some of the variability we might otherwise have seen due to lower socioeconomic status in this state. Indeed, a recent study using the ORCA suggested just this (Kennedy, Rhoads, & Leu, 2015). Had this study investigated each state individually, an effect for socioeconomic status may have been observed.

Finally, another important consideration regarding the socioeconomic data in the present study is that the socioeconomic data was collected on the school-level alone rather than for each individual student. The conditional model for the second research question indicated that some significant variability still remained within schools. Individual socioeconomic status levels may have contributed to this variability, thereby accounting for some of this unexplained, within-school variance. While this data may be difficult to obtain, it would be very useful. Future studies should attempt to obtain individual socioeconomic status data to better understand the relationship between socioeconomic status and critical evaluation during online reading.

Evaluating Data Loss

The researcher was concerned about the loss of data between those students who had no ORCA-Virtual data and those who had a complete ORCA-Virtual score, as well as between those students who had a partial ORCA-Virtual score and those who had a complete ORCA-Virtual score. As such, two sets of regression analyses were conducted on six different variables that were of interest in the primary analyses: Prior Knowledge, Gender, Offline Reading, FRPL, and ORCA score (total ORCA-MC score in the first set of analyses and total ORCA-Virtual Locate score in the second set of analyses, since these were the ORCA scores that were available for each set).

These two sets of secondary analyses suggested that excluding these students (those with no ORCA-Virtual data and those with only partial ORCA-Virtual data) did not affect the results. There were no significant differences on any of these variables except for FRPL. However, in the primary analyses, there were no significant differences for FRPL.

Implications

Interestingly, it appears that Critical Evaluation may have unique properties apart from location, synthesis, and communication during online reading and research tasks. Critical Evaluation appears to be a related but unique construct to the other three skill areas that is relatively difficult overall and especially compared to Location and Synthesis.

Additionally, as with offline reading, individual difference variables have important effects on online critical evaluation in science, though in somewhat different ways. Prior knowledge and offline reading skills may be important to online critical evaluation but less so than in offline environments. While the present study found a similar pattern with gender in online critical evaluation as with offline reading, the gap may be smaller, with the science skill

area and the online environment helping to lessen that gap. Finally, socioeconomic status of schools appears to be less important for online critical evaluation than for offline reading and evaluation. This may make it easier to help all students, rather than just wealthier students, gain the skills they need for critically evaluating the credibility of online information.

Importance of Focusing on Discipline-Specific Online Critical Evaluation Skills When Teaching and Assessing Online Reading

As prior studies have found, critical evaluation is an important online reading skill that significantly impacts students' overall online reading ability (Goldman et al., 2012; McVerry, 2013). Additionally, in science specifically, critical evaluation skills are central to understanding new information, since a reader must evaluate the credibility of an argument before incorporating information into existing understanding (Halverson, Siegel & Freyermuth, 2010). Given that the present study, as well as past studies (Goldman et al., 2012; Forzani & Burlingame, 2012; McVerry, 2013) have found that students are not especially skilled in this area, it is imperative that teachers focus on teaching these key skills to students. Some research has begun to investigate methods for teaching students these skills (Kingsley & Tancock, 2014; McVerry, 2012). If we are to teach students these skills in efficient and effective ways, research should continue to examine the efficacy of strategies for teaching these skills, particularly the ways in which strategies work for different types of students with different individual differences.

Additionally, in order to effectively teach students online critical evaluation skills, we will need to create better assessments in this skill area. The ORCAs are one of the first assessments to measure online reading skills and have paved the way for assessments of online reading. New assessments, both formal and informal, will need to be accessible to teachers, easy to use and score, and will need to provide information about how well a student performs in

small, specific areas of online critical evaluation. In addition, assessments should be targeted to specific disciplinary areas to better evaluate the discipline-specific skills students need in different fields of study.

Possibility for Unique Influences of Individual Difference Variables in an Online Environment

As with offline reading (Afflerbach, 2015), individual difference variables have important impacts on students' ability to evaluate online information. This also makes it likely that individual difference variables matter for online reading overall, as well, since critical evaluation is a significant predictor of overall online reading (Goldman et al., 2012; McVerry, 2013). Additional research should examine the ways in which other individual difference variables affect online critical evaluation, which would aid educators in developing curriculum for online critical evaluation.

Prior knowledge: Teaching students prior domain knowledge when teaching the critical evaluation of online information in science may be helpful. Perhaps one of the best places to start when determining how best to teach students to critically evaluate online texts is with discipline-specific prior knowledge. More research needs to be conducted to examine the impact of prior knowledge on online critical evaluation skills, particularly in the area of science specifically. However, it appears that prior domain knowledge has a significant impact on students' abilities to critically evaluate online information. Moreover, implementing instruction of domain-specific prior knowledge may be relatively achievable for teachers since this means a focus on a specific area of information for teachers and students.

If prior domain knowledge is a prerequisite for critically evaluating online information, then helping students gain a solid foundation in a given scientific domain before teaching critical

evaluation skills, or even in conjunction with teaching these skills, may be particularly helpful to students learning how to evaluate online information. Once students have some solid prior domain knowledge, intertwining prior domain knowledge lessons with online critical evaluation lessons to create an iterative learning process may also be useful to students for helping them draw connections between these two areas. These lessons can be further integrated with broader disciplinary curriculum.

For example, students learning about eye health might learn about the concept of focusing, a concept which has both an everyday use but also a specialized use in the context of the lenses in our eyes. Prior to evaluating the reliability of online information about eye health, students might learn about lenses and focusing. These concepts might be further integrated with concepts they have already learned about in other contexts; for example, lenses, which are used in many places besides our eyes. Once students understand the concept of focusing as it relates to lenses and, more specifically, to our eyes, they will better be able to evaluate the logic of the argument the author of the video games and eyesight critical evaluation page (see Figure 2.9) uses to explain how video games hurt focusing in eyes. It is only with some background knowledge of focusing and lenses that the student can attempt to determine whether this argument makes sense. Once students start evaluating the argument at a given webpage, they may do a side search to learn more about focusing or to gather scientific evidence on how video games affect focusing, an important aspect of evaluating scientific information. In so doing, students will continue to build their domain knowledge about eye health while also continuing to evaluate the reliability of information at the given webpage.

Of course, this knowledge about focusing needs to be integrated with many other pieces of both domain-specific knowledge and other types of prior knowledge as students evaluate the

empirical evidence the author uses, the author's and publisher's credentials and expertise, the currency of information, and the presentation and structure of the information, all important aspects of evaluating online information, particularly in science.

Additional skills related to the specific context of reading online in general may be important as well (McVerry, 2013). In this context, these skills might include knowing how to click on an author's name in order to navigate to a secondary, author biography page ("About the Author page"), understanding what different types of URLs mean, knowing how to gather additional information by clicking on hyperlinks and conducting side searches to gather additional information, knowing about different common online publishers, and knowing how to evaluate empirical evidence that is cited by an author. The present study did not examine the impact of these types of Internet context-specific types of prior knowledge. Given that these are likely important types of prior knowledge, future research should attempt to separate the effects of these different types of prior knowledge and investigate how different types of prior knowledge might affect students' abilities in online critical evaluation. It is possible that these types of prior knowledge may be less discipline-specific and therefore could also be important pre-requisites for teaching online critical evaluation in general.

Gender. In the present study, gender played a significant role in students' ability to critically evaluate online information in science. Research on gender in reading as well as research on gender in science is inconclusive and changing, particularly in the field of science and with the new literacies readers face in an Internet context. The present study adds to this conversation by providing specific and complex information about how boys and girls perform in an online research and comprehension task in science. For boys and for girls, the findings

from the present study may show exciting trends in this area, trends that can be leveraged for teaching and learning.

An online environment may positively impact boys' reading achievement. It may be that an online environment works as a mediating factor in the gender gap that exists in offline reading. While boys tend to perform better on assessments of informational texts than literary ones (Mullis, Martin, Foy & Drucker, 2011), there are still very large national and international gender gaps in offline reading (Chudowsky & Chudowsky, 2010; Brozo et al., 2014). The present study showed a relatively small gender gap for critical evaluation in an online environment with informational science text. These findings are similar to those from a recent study where girls outperformed boys in both the paper-based and computer-based PISA reading assessments. However, the gap between boys and girls was smaller in the computer-based assessment than in the paper-based one (Borgonovi, 2016).

Educators may be able to leverage boys' interest and abilities in science, informational reading, and digital reading to help them improve their reading skills. Citing Newkirk (2006), a group of members from the PISA/PIRLS Task Force (Brozo et al., 2014) suggested that supporting boys' interest and ability in digital texts could help close the gender gap in reading. The present study thus paves the way for additional research that looks at whether and how boys' interest and abilities in these areas might help mitigate the gender gap. Research on instructional strategies in this area is especially needed so that we can determine the best ways to leverage online informational text to close the gender gap.

Researchers should pay particular attention to future studies in this area to see if, as in the present study, a smaller gender gap for online compared to offline reading is born out in future studies as well. For example, it will be interesting to see how the gender results for the 2016

ePIRLS online informational reading assessment (Mullis & Martin, 2015) compare to those for the 2016 PIRLS Informational assessment, an offline reading assessment. Online reading may be an one area that can help address struggles with educating boys in reading, a problem that reading educators have long faced (Smith & Wilhelm, 2006).

An online inquiry approach may positively impact girls' science achievement.

Similarly, in the area of science, online science literacy may be one area that can be leveraged to help girls achieve greater goals in science. In the present study, girls performed better than boys despite the scientific nature of the research tasks.

One reason for this may be that the tasks, and thus the critical evaluation items, were framed as reading tasks, and girls tend to perceive of themselves as good readers compared to boys (Wigfield et al., 1997). Given that students' self-efficacy plays an important role in their achievement (Eccles, Wigfield, & Schiefele, 1997) and assessment performance (see Ehrlinger & Dunning, 2003), this task-framing may have helped girls in the present study. It may be that girls' lack of self-confidence in their own science abilities negatively impacts their performance (OECD, 2015). If this is the case, the reading frame of the tasks in the current assessment may have provided girls with self-confidence in their abilities and acted as a mediating variable, leading girls to have better achievement on these tasks than they may otherwise have had in other science tasks.

Another, related, reason may be that the critical evaluation items themselves involved a heavy degree of reading, which helped girls despite the scientific content of the texts. Indeed, there is some evidence that girls outperform boys in the thinking processes required for doing science (compared to the content). These thinking process tasks may be heavily entwined with literacy, especially compared to the content domain tasks. For example, in the 2011 TIMSS

assessment, girls, on average across all participating countries, outperformed boys at the eighth grade level in all three cognitive domains, knowing, applying, and reasoning, which included the thinking processes required for doing science. At the fourth grade level, girls outperformed boys in the reasoning dimension, which includes critically evaluating information (Martin et al., 2012). Interestingly, in the U.S. specifically, fourth grade and eighth grade boys outperformed fourth grade and eighth grade girls in both the knowing and applying dimensions, but there was no difference between boys and girls in the reasoning dimension, the dimension that includes critical evaluation. This was true despite the fact that both fourth grade and eighth grade boys outperformed fourth grade and eighth grade girls in science in the same year, on average across all participating countries (Martin et al., 2012).

Indeed, some have suggested that science education for girls may benefit from framing science in terms of literacy, and especially critical literacy, for these reasons (Gilbert, 2001; Letts, 2001). Educators may be able to leverage girls' interest in and ability with reading to help girls become more interested in science and achieve better outcomes in science. These are important goals for bringing gender equity to the field of science. It is possible that framing science as both content and literacy – in both its fundamental and its derived sense – may benefit both boys and girls and help to close gender gaps in both reading and science, particularly when students engage with science through online spaces.

Finally, a third possibility is that girls benefited from the socially context of a collaborative online environment. One qualitative study in particular that studied girls' science learning in an online environment suggested that contextualizing scientific knowledge and situating activities within a social context is important for students' science learning (Kang &

Lundeberg, 2010). More research should be conducted to explore the usefulness of online social contexts, which involve communication and collaboration, for engaging females in science.

Offline reading skills are important but not sufficient for critically evaluating online information in science. Findings from this study can inform thinking about a new literacies theory of online research and comprehension. Some have argued that online reading is not much different from offline reading and that the skills and strategies that are required for offline reading are the same as those required for online reading, particularly in regards to critical evaluation (Fitzgerald, 1997; McLaughlin & DeVogd, 2003). Others, however, have argued that online reading requires similar but more complex strategies or even the use of entirely new skills and strategies (Afflerbach & Cho, 2009; Coiro, 2011; Leu, 2005; McVerry, 2013). The present study lends further evidence to the argument by showing that one important aspect of online reading, that of online critical evaluation, requires new skills and strategies.

Offline reading appears to contribute significantly to online critical evaluation. However, the effect is not especially large. We should be cautious about how we interpret these findings. The present study only examined the effects of offline reading on one aspect of online reading, that of critical evaluation. While critical evaluation appears to be an important predictor of overall online reading ability (Goldman et al., 2012; McVerry, 2013), other skill areas are involved in online reading, including locating, synthesizing, and communicating. Additional research should investigate the ways in which proficiency with offline evaluating may transfer to online evaluating and vice versa. As well, research should investigate the ways in which proficiency with online evaluating may transfer to both offline and online reading.

Developing a Model for Disciplinary Online Research and Comprehension

Currently, theories of disciplinary literacy generally ignore a pervasive and critical context: that of the Internet. Given that there may be particular aspects of literacy that are unique to an online science context, this is an important area for development. To what extent can we make an argument for expanding Shanahan & Shanahan's (2008) disciplinary literacy theory to form an online disciplinary literacy theory, especially for science, or for expanding Leu et al.'s (2013) theory of online research and comprehension to form a theory of disciplinary online research and comprehension?

Rather than situating one aspect of a model such as this (disciplines, literacy, or the Internet) as more central than other aspects, such a model might situate disciplines, literacy, and the Internet each in the service of one another, as Pearson, Moje, and Greenleaf (2010) suggest that literacy and science might be productively viewed. While the present study offers one potential and initial model of online reading and research in disciplinary literacy (see Figure 2.6) that includes critical evaluation, more research is necessary for developing a more complete model. This means that more research is needed for understanding the ways in which texts, readers, activities, and contexts interact during online reading in particular disciplines.

Additional research for developing a theory such as this, for science specifically, might further explore the particular and important role of critical evaluation. The present study showed that critical evaluation played a unique role in students' ability to comprehend during online reading in science. This may have been due to the fact that critical evaluation is a particularly important skill in an online environment. This may also have been partly due to the fact that critical evaluation is an especially important skill for science, compared to other skill areas. If both of these are true, then critical evaluation is a particularly essential skill for an online science

environment. However, these issues need to be explored in greater depth and breadth, and so important questions remain to be answered. To what extent is critical evaluation a central skill for an online science environment, and in what ways does it function in relation to other skills required in such an environment? Also, to what extent is critical evaluation an especially important skill for science, compared to other disciplines?

Further research for developing a theory of disciplinary online research and comprehension might focus particular attention on the “reader” aspect of the model. Specifically, research might focus on developing an understanding of the repertoire of skills and strategies readers need as they conduct research and comprehend during online reading in science rather than on critical evaluation skills alone. This set of skills and strategies could then be used in instruction, assessment, and further research.

Another important aspect of the “readers” part of the model that needs to be explored to a greater extent is that of individual differences. Disciplinary literacy theories largely ignore the potential effects of individual difference variables as they relate to specific disciplines. As the present study shows, there may be specific interactions between achievement and individual difference variables that are unique to particular disciplines, and even that are unique to particular disciplines within an online environment. Expanding current theories to include individual differences would aid more students in developing the skills they need by considering the potential challenges and strengths different students bring to various kinds of disciplinary activities.

Finally, while much research has investigated the online reading process, research is needed to better understand the ways in which particular online disciplinary texts, activities, and contexts may differ from offline ones, and the ways in which different disciplines may differ

from one another in an online environment. Research such as this can help us to better develop a model for disciplinary online research and comprehension. A model such as this can provide direction for instruction, assessment, and further research that ultimately will help all students gain the skills they need for online research and comprehension in science.

Addressing the Challenges and Promises of Individual Differences in Critical Evaluation During Online Reading in Science

In the information age in which we now live, the ability to evaluate the reliability of a vast amount of online information is essential, particularly for science (Goldman et al., 2012; Wiley et al., 2009; Tsai et al., 2012). Those who learn how to do so well will gain a significant advantage over those who do not. This advantage will help to define students' futures in positive ways, affecting both their personal and working lives. Unless we work to provide these skills to all students, the ability to critically evaluate online information will deepen the already significant divides between higher- and lower-ability readers.

Critical evaluation skills appear to be an important predictor of online research and comprehension (Goldman et al., 2012; McVerry, 2013), as well as an essential and fundamental aspect of scientific ability (Halverson, Siegel & Freyermuth, 2010). Given this, critical evaluation may be a key area with which to start when providing equal educational opportunities to all students and closing achievement gaps in both online and offline reading. At the same time, critical evaluation may also be an important area to focus on when preparing both boys and girls for a world in which scientific literacy skills, particularly those required by the Internet, are fundamental for work, life, and the nation's progress (National Science and Technology Council, 2013).

We already see two of these divides in online research and comprehension ability emerging between wealthier and poorer students (Leu et al., 2015) and, in source evaluation specifically, between boys and girls (in the present study). Regarding the income gap for reading, the Internet is a space that appears, at the moment, to deepen the rift we see in offline reading skills between students from wealthy and poor backgrounds. If we address this problem, however, and prepare all students for successful online reading, the Internet could become a space that reverses this rift. Regarding the gap between boys and girls, we may already see this happening, for offline and online reading. A similar thing may be true for prior knowledge and offline reading skills. Those students who have these skills appear to have an advantage over those who do not, which could further increase gaps between students in offline and online reading skills.

Thus, all four of these areas (economic background, gender, prior knowledge, and offline reading ability) have important consequences for online critical evaluation abilities in science and for providing all students with equal educational opportunities in reading and science. If we do not teach critical evaluation skills well, with an eye towards addressing the issues particular to individual difference areas such as these, critical evaluation skills in science will likely become tools in deepening these divides and disadvantaging poorer students, one gender over another, or students who lack prior knowledge and offline reading skills. If, however, we address the challenges we face with regards to these areas, as well as other areas that have implications for individual differences, critical evaluation skills can be leveraged as an important tool in helping all students gain the skills they need, at the intersection of literacy and science in online spaces, to engage with society on a high level, in both personal and professional ways. This, indeed, is a valuable goal, and would be a significant accomplishment for our nation.

At the 2015 White House Science Fair, President Barack Obama remarked:

...the United States has always been a place that loves science. We've always been obsessed with tinkering and discovering and inventing and pushing the very boundaries of what's possible. That's who we are. It's in our DNA. Technological discovery helped us become the world's greatest economic power...scientific...breakthroughs are not just our past [but] also our future...and that involves us as a society making the kind of investments that are going to be necessary for us to continue to innovate for many, many years to come" (President Obama, 2015).

One of the most important ways in which we can invest in our future and ensure scientific innovation for years to come is by teaching the scientific literacy skills necessary for engaging with online science environments, particularly online critical evaluation skills in science. If scientific literacy in its fundamental sense lies at the heart of what it means to do science, then the extent to which all students can evaluate online information in science will define their capacity for scientific innovation, and, in turn, define our nation's capacity for progress and equality. If we fail to invest in teaching these important skills to our students, we risk moving against innovation, progress, opportunity, and equality. If, however, we invest wisely, providing all students with the opportunity to learn these skills well, these skills will become a leveraging force that will help to position our nation as a major player in the move towards progress and equality and our students as both beneficiaries of and contributors to this process. Indeed, the ability to evaluate online information in science will help to define the contours of our students' and our nation's futures, contours that, like science, literacy, and the Internet, are part and parcel of one another.

REFERENCES

- Abdi, H. (2007). Bonferroni and Sidak corrections for multiple comparisons. In N.J. Salkind (Ed.), *Encyclopedia of measurement and statistics* (pp. 103-107). Thousand Oaks, CA: Sage. doi: 10.4135/9781412952644
- Afflerbach, P. (1986). The influence of prior knowledge on expert readers' importance assignment process. In J. A. Niles, & R. V. Lalik (Eds.), *National reading conference yearbook. Solving problems in literacy: Learners, teachers and researchers*, Vol. 35 (pp. 30-40). Rochester, New York: National Reading Conference.
- Afflerbach, P. (2015). An overview of individual differences in reading: Research, policy, and practice. In P. Afflerbach (Ed.), *Handbook of individual differences in reading: Reader, text, and context*.
- Afflerbach, P. (2007). *Understanding and using reading assessment, K–12*. Newark, DE: International Reading Association.
- Afflerbach, P. & Cho, B. (2009). Identifying and describing constructively responsive comprehension strategies in new and traditional forms of reading. In S. Israel & G. Duffy (Eds.), *Handbook of research on reading comprehension* (pp. 69-90). New York: Routledge.
- Afflerbach, P., & Cho, B.-Y. (2010). Determining and describing reading strategies: Internet and traditional forms of reading. In H.S. Waters & W. Schneider (Eds.), *Metacognition, strategy use, and instruction* (pp. 201 – 225). New York, NY: Guilford .Alexander, P. A. (2003). The development of expertise: the journey from acclimation to proficiency. *Educational Researcher*, 3(8), 10-14.
- Agosto, D.E. (2002). A model of young people's decision-making in using the Web. *Library &*

- Information Science Research*, 24(4), 311-341. Doi: 10.1016/S0740-8188(02)00131-7
- Alexander, J., & Tate, M. (1996). Teaching critical evaluation skills for World Wide Web resources. *Computers in Education*, 16(10), 49-55.
- Al Otaiba, S., & Fuchs, D. (2002). Characteristics of children who are unresponsive to early literacy intervention: A review of the literature. *Remedial and Special Education*, 23(5), 300–316.
- Alvermann, D.E., Smith, L.C., & Readence, J.E. (1985). Prior knowledge activation and the comprehension of compatible and incompatible text. *Reading Research Quarterly*, 20, 420-436.
- Anderson, L.W. (Ed.), Krathwohl, D.R. (Ed.), Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., & Wittrock, M.C. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives (Complete edition). New York: Longman.
- Anderson, R.C., & Pearson, P.D. (1984). A schema-theoretic view of basic processes in reading comprehension. In P.D. Pearson (Ed.), *Handbook of reading research* (pp. 255-291). New York, NY: Longman.
- Bailey, M.J., & Dynarski, S.M. (2011). Gains and gaps: Changing inequality in U.S. college entry and completion (National Bureau of Economic Research Working Paper No. 17633). Cambridge, MA: National Bureau of Economic Research. Retrieved from www.nber.org/papers/w17633.pdf
- Baker, L. & Beall, L. (2009). Metacognitive processes and reading comprehension. In S. Israel and G. Duffy (Eds.), *Handbook of research on reading comprehension* (pp. 373-388). New York: Routledge.

- Baldwin, S., Peleg-Bruckner, Z., & McClintock, A.H. (1985). Effects of topic interest and prior knowledge on reading comprehension. *Reading Research Quarterly*, 20(4), 497-504.
- Barzilai, S., & Zohar, A. (2012). Epistemic thinking in action: Evaluating and integrating online sources. *Cognition and Instruction*, 30(1), 39–85. doi:10.1080/07370008.2011.636495
- Bazerman, C. (1985). Physicists reading physics: Schema-laden purposes and purpose-laden schema. *Written Communication*, 2, 3-23.
- Bereiter, C., & Bird, M. (1985). Use of thinking aloud in identification and teaching of reading comprehension strategies. *Cognition and Instruction*, 2, 131-156.
- Bilal, D. (2000). Children's use of the Yahoo!igans! Web search engine: Cognitive, physical, and affective behaviors on fact-based search tasks. *Journal of the American Society for Information Science*, 51, 646–665. Retrieved from <http://ithreads.pbworks.com/f/yhoo1.pdf>
- Birch, H., Looi, M.K., & Stuart, C. (2013). *The Big questions in science: The quest to solve the great unknowns*. London: André Deutsch.
- Bonner, J., & Holliday, W. (2006). How college science students engage in note-taking strategies. *Journal of Research in Science Teaching*, 43, 786–818.
- Borgonovi, F. (2016). Video gaming and gender differences in digital and printed reading performance among 15-year-old students in 26 countries. *Journal of Adolescence*, 48, 45-61. doi:10.1016/j.adolescence.2016.01.004
- Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, 53, 371–399.
- Brady, S.A., Braze, D., & Fowler, C.A. (2011). Explaining individual differences in reading. New York: Psychology Press.

- Brand-Gruwel, S., Wopereis, I., & Vermetten, Y. (2005). Information problem solving by experts and novices: Analysis of a complex cognitive skill. *Computers in Human Behavior*, 21(3), 487-508.
- Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of verbal learning and verbal behavior*, 11, 717-726.
- Braten, I., Strømsø, H. I., & Britt, M. A. (2009). Trust matters: examining the role of source evaluation in students' construction of meaning within and across multiple texts. *Reading Research Quarterly*, 44, 6-28. doi: 10.1598/RRQ.41.1.1
- Bray Speth, E., Momsen, J.L., Moyerbrailean, Ebert-May, D., Long, T.M., Wyse, S. & Linton, D. (2010). 1, 2, 3, 4: infusing quantitative literacy into introductory biology. *CBE Life Sciences Education*, 9, 323–332.
- Braze, D., Tabor, W., Shankweiler, D. P., & Mencl, W. E. (2007). Speaking up for vocabulary: Reading skill differences in young adults. *Journal of Learning Disabilities*, 40(3), 226–243.
- Brickman, P., Gormally, C., Francom, G., Jardeleza, S.E., Schutte, V.G.W., Jordan, C., & Kanizay, L. Media-savvy scientific literacy: Developing critical evaluation skills by investigating scientific claims. *The American Biology Teacher* 74(6): 374-379.
- Brigandt, I. Why the difference between explanation and argument matters to science education. *Science & Education*, 25(3), 251-275. Retrieved from https://www.ualberta.ca/~brigandt/Why_the_difference_between_explanation_and_argument_matters.pdf
- Britt, M.A., & Gabrys, G.L. (2001). Teaching advanced literacy skills for the World Wide Web. In C.R. Wolfe (Ed.), *Learning and teaching on the World Wide Web* (p. 73-90). San Diego,

CA: Academic. Doi:10.1016/B978-012761891-3/50007-2

- Britt, M.A., Richter, T., & Rouet, J-F. (2014). *Scientific literacy: The role of goal-directed reading and evaluation in understanding scientific information. Educational Psychologist, 49*(2), 104-122.
- Bromme, R., Kienhues, D., & Porsch, T. (2010). Who knows what and who can we believe? Epistemological beliefs are beliefs about knowledge (mostly) attained from others. In L. Bendixen & F. Feucht (Eds.), *Personal epistemology in the classroom: Theory, research, and implications for practice* (pp. 163-193). Cambridge: Cambridge University Press.
- Brooks, T. (2011). The effects of single-gender education on middle school female science achievement and science-related attitude. (Doctoral Dissertation). Walden University, Minneapolis, MN.
- Brotman, J.S., & Moore, F.M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching, 45*(9), 971-1002.
- Brozo, W.G., Sulkunen, S., Shiel, G., Garbe, C., Pandian, A., & Valtin, R. (2014). Reading, gender, and engagement: Lessons from five PISA countries. *Journal of Adolescent and Adult Literacy, 57*(7), 584-593. doi: 10.1002/jaal.291
- Cain, K., Oakhill, J.V., Barnes, M.A., & Bryant, P.E. (2001). Comprehension skill, inference making ability, and the relation to knowledge. *Memory & Cognition, 29*, 850-859.
- Caldas, S. J., and C. Bankston III. 1997. "Effect of School Population Socioeconomic Status on Individual Academic Achievement." *Journal of Educational Research 90*:269–77.
- Caswell, L.J., & Duke, N.K. (1998). Non-narrative as a catalyst for literacy development. *Language Arts, 75*, 108-117.
- Castells, Manuel (2000). *The Rise of the Network Society*, (second ed.). Oxford: Blackwell.

- Catts, H.W. & Adlof, S. (2011). Phonological and other language deficits associated with dyslexia. In S.A. Brady, D. Braze, & C.A. Fowler (Eds.), *Explaining individual differences in reading* (pp.137-151). New York: Psychology Press.
- Cervetti, G. N., Pearson, P. D., Bravo, M. A., & Barber, J. (2006). Reading and writing in the service of inquiry-based science. In R. Douglas, M. Klentschy, & K. Worth (Eds.), *Linking science and literacy in the K–8 classroom*. Arlington, VA: National Science Teachers Association.
- Chi, M.T.H. (1978). Knowledge structures and memory. In R.S. Siegler (Ed.), *Children's thinking: What develops?* (pp. 73-96). Hillsdale, NJ: Erlbaum.
- Chi, M.T.H., Feltovich, P.J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, 5 (2), 121 – 152. doi: 10.1207/s15516709cog 0502_2
- Chiu, M. M., & Chow, B. W. Y. (2010). Culture, motivation, and reading achievement: High school students in 41 countries. *Learning and Individual Differences*, 20(6), 579-592.
- Cho, B-Y. (2014). Competent adolescent readers' use of Internet reading strategies: A think-aloud study. *Cognition & Instruction*, 32(3), 253-289. doi: 10.1080/07370008.2014.918133
- Chudowsky, N., & Chudowsky, V. (2010). *Are there differences in achievement between boys and girls?* Washington, DC: Center on Education Policy. Retrieved from <http://cep-dc.org/displayDocument.cfm?DocumentID=322>
- Chung, M., Oden, R.P., Joyner, B.L., Sims, A., & Moon, R.Y. (2012). Safe infant sleep recommendations on the Internet: Let's Google it. *The Journal of Pediatrics*, 161, 1080-1084. doi: 10.1016/j.jpeds.2012.06.004

- Coiro, J. (2011). Predicting reading comprehension on the Internet: Contributions of offline reading skills, online reading skills, and prior knowledge. *Journal of Literacy Research*, 43 (4), 352 – 392. doi: 10.1177/1086296X11421979
- Coiro, J., Coscarelli, C., Maykel, C., & Forzani, E. (2015). Investigating criteria that seventh graders use to evaluate the quality of online information. *Journal of Adolescent & Adult Literacy*, 59(3). Doi:10.1002/jaal.448
- Coiro, J., Castek, J., Guzniczak. (2011). Uncovering online reading comprehension processes: Two adolescents reading independently and collaboratively on the Internet. In *Sixtieth yearbook of the Literacy Research Association*, ed. R. Jimenez, V. Risko, M. Hundley, and D.W. Rowe, 354-69. Oak Creek, WI: National Reading Conference.
- Coiro, J., & Dobler, E. (2007). Exploring the online reading comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet. *Reading Research Quarterly*, 42 (2), 214 – 257 . doi: 10.1598/RRQ.42.2.2
- Coiro, J., Guzniczak, L., Castek, J., & Bradshaw, C. (2011). Understanding functional and dialogic interactions among dyads of seventh graders as they read for information on the Internet. Alternative symposium presented at the 61st annual conference of the Literacy Research Association, Nov. 30-Dec. 3, Jacksonville, FL.
- Coleman, J. S., E. Q. Campbell, C. J. Hobson, J. McPartland, A. M. Mood, F. D. Weinfeld, and R. L. York. 1966. *Equality of Educational Opportunity*. Washington, DC: US Government Printing Office.
- Common Core State Standards Initiative (2010). *Common Core State Standards Initiative: Preparing America's Students for College and Career*. Retrieved from <http://www.corestandards.org>

- Cope, B., Kalantzis, M., & Abd-El-Khalick, F. (2013). *E-Learning and Digital Media*, 10(4), 420-441. doi.10.2304/elea.2013.10.4.420
- Cromley, J.G., Snyder-Hogan, L.E., Luciw-Dubas, U. (2010). Comprehension of scientific text: A domain-specific test of the direct and inferential mediation model of reading comprehension. *Journal of Educational Psychology*, 102(3), 687-700.
- Cui, W., Bruner-Sedransk, E., & Sedransk, N. (2014). *Offline Reading Basic Assessment: Combining 4th and 8th Grade NAEP Items* (Report No. 13). Retrieved from the New Literacies Research Lab website: <http://www.orca.uconn.edu/>
- DeBoer, G.E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, 37(6), 582-601.
- de Klerk, S., Veldkamp, B. P., & Eggen, T. J. (2015). Psychometric analysis of the performance data of simulation-based assessment: A systematic review and a Bayesian network example. *Computers & Education*, 85, 23-34.
- DeStefano, D., & LeFevre, J. (2007). Cognitive load in hypertext reading: A review. *Computers in Human Behavior*, 23, 1616-1641.
- Diakidoy, I.N., & Kendeou, P. (2001). Facilitating conceptual change in astronomy: A comparison of the effectiveness of two instructional approaches. *Learning & Instruction*, 11, 1-20.
- Dole, J., Duffy, G., Roehler, L., & Pearson, P.D. (1991). Moving from the old to the new: Research on reading comprehension instruction. *Review of Educational Research*, 61(2), 239-264.

- Duke, N.K., & Pearson, P.D. (2002). Effective practices for developing reading comprehension. In A.E. Farstrup & S.J. Samuels (Eds.), What research has to say about reading instruction, 3rd ed. (pp. 205-242). Newark, DE: International Reading Association.
- Duschl, R.A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education*, 38(1), 39-72.
- Duschl, R.A., Schweingruber, H.A., & Shouse, A.W. (2007). Taking science to school: Learning and teaching science in Grades K-8. National Academy of Sciences. National Research Council. Retrieved online at <http://www.nap.edu/catalog/11625.html>
- Duthie, C. (1996). True stories: Nonfiction literacy in the primary classroom. York, ME: Stenhouse.
- Driver, R., Newton, P., and Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, 84, 287-312.
- Eagleton, M., & Dobler, E. (2007). Reading the Web: Strategies for Internet Inquiry. New York: The Guilford Press.
- Eagleton, M., Guinee, K., & Langlais, K. (2003). Teaching Internet literacy strategies: The hero inquiry project. *Voices from the Middle*, 10(3), 28-35.
- Eastin, M. S., Yang, M.-S., & Nathanson, A. I. (2006). Children of the net: An empirical exploration into the evaluation of internet content. *Journal of Broadcasting & Electronic Media*, 50, 211-230.
- Eccles, J. S., Wigfield, A., & Schiefele, U. (1997). Motivation to succeed. In W. Damon & N. Eisenberg (Eds.), *Handbook of child psychology* (Vol. 3, pp. 1017-1095). New York, NY: Wiley.
- Eggins, S. (1994). *An introduction to systemic functional linguistics*. London: Pinter.

- Ehrlinger, J., & Dunning, D. (2003). How chronic self-views influence (and potentially mislead) estimates of performance. *Journal of Personality and Social Psychology*, 84(1), 5–17.
- Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review*, 5(1), 1-24.
- Ericsson, K.A., & Simon, H.A. (1999). *Protocol analysis: Verbal reports as data* Rev ed. Cambridge, MA: MIT Press.
- Fabos, B. (2008). The price of information: Critical literacy, education, and today's Internet. In J. Coiro, M. Knobel, C. Lankshear, & D.J. Leu (Eds.), *Handbook of research on new literacies* (pp. 839-870). Mahwah, NJ: Erlbaum.
- Fang, Z. (2005). Scientific literacy: A systemic functional linguistics perspective. *Science Education*, 89(2), 335-347. doi: 10.1002/sce.20050
- Farris, P.J., Werderich, D.E., Nelson, P.A., & Fuhler, C.J. (2009). Male call: Fifth-grade boys' reading preferences. *The Reading Teacher*, 63(3), 180–188. doi:10.1598/RT.63.3.1
- Fitzgerald, M.A. (1997). *Evaluating information: An information literacy challenge*. *School library media research*. Retrieved from http://www.ala.org/aasl/sites/ala.org/aasl/files/content/aaslpubsandjournals/slr/vol2/SLMR_EvaluatingInformation_V2.pdf
- Flangin, A.J., & Metzger, M.J. (with Hartsell, E., Markov, A., Medders, R., Pure, R., & Choi, E.) (2010). *Kids and credibility: An empirical examination of youth, digital media use, and information credibility*. Cambridge, MA: MIT Press.
- Forzani, E., & Burlingame, C. (2012, December). *Evaluating Representative State Samples of Seventh-Grade Students' Ability to Critically Evaluate Online Information*. Paper presented at the 62nd Annual Conference of the Literacy Research Association, San Diego, CA.

- Forzani, E., Maykel, C., Flake, J., & Leu, D.J. (in preparation). *How well do seventh graders evaluate the quality of online information during an authentic online research task?: Investigating students' abilities using three assessment formats*. University of Connecticut, Storrs, CT.
- Fuller, B., and P. Clarke. 1994. Raising school effects while ignoring culture? Local conditions and the influence of classroom tools, rules and pedagogy. *Review of Educational Research* 64:119-57.
- Gilabert, R., Martinez, G., & Vidal-Abarca, E. (2005). Some good texts are always better: Text revision to foster inferences of readers with high and low prior background knowledge. *Learning and Instruction*, 15, 45–68.
- Gilbert, J. (2001). Science and its 'other': Looking underneath 'woman' and 'science' for new directions in research on gender and science education. *Gender and Education*, 13(3), 291-305.
- Gilbert, J., & Calvert, S. (2003). Challenging accepted wisdom. Looking at the gender and science education questions through a different lens. *International Journal of Science Education*, 25(7), 861-878.
- Goldman, S., Braasch, J., Wiley, J., Graesser, A., & Brodowinska, K. (2012). Comprehending and learning from Internet sources: Processing patterns of better and poorer learners. *Reading Research Quarterly*, 47, 356-381. doi: 10.1002/RRQ.027
- Goldman, S.R., & Saul, E. (1990). Flexibility in text processing: A strategy competition model. *Learning & Individual Differences*, 2, 181-219.

- Goldman, S. R., Wiley, J., & Graesser, A. C. (2005, April). Literacy in a knowledge society: constructing meaning from multiple sources of information. Paper presented at American Educational Research Association. Montreal, Canada.
- Graesser, A.C., Singer, M. & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review*, 101, 371-395.
- Graesser, A.C., Wiley, J., Goldman, S.R., O'Reilly, T., Jeon, M., McDaniel, B. (2007). SEEK web tutor: Fostering a critical stance while exploring the causes of volcanic eruption. *Metacognition Learning*, 2, 89-105. doi: 10.1007/s/11409-007-9013-x
- Greenhow, C., Robelia, B., & Hughes, J. (2009). Web 2.0 and classroom research: What path should we take now? *Educational Researcher*, 38(4), 246–259. doi: 10.3102/0013189X09336671
- Guinee, K., Eagleton, M. B., & Hall, T. E. (2003). Adolescents' Internet search strategies: Drawing upon familiar cognitive paradigms when accessing electronic information sources. *Journal of Educational Computing Research*, 29, 363–374.
- Guthrie, J.T., & McCann, A.D. (1997). Characteristics of classrooms that promote motivations and strategies for learning. In J. T. Guthrie & A. Wigfield (Eds.), *Reading engagement: Motivating readers through integrated instruction* (pp. 128-148) Newark, DE: International Reading Association.
- Halliday, M. A. K. (1994). *An introduction to functional grammar* (2nd ed.). London, UK: Edward Arnold.
- Halliday, M.A.K., & Martin, J.R. (1993). *Writing science: Literacy and discursive power*. Pittsburgh, PA: University of Pittsburgh Press.

- Halverson, K.L., Siegel, M.A., & Freyermuth, S.K. (2010). Non-science majors' critical evaluation of websites in a biotechnology course. *Journal of Science Educational Technology, 19*, 612-620. Doi: 10.1007/s10956-010-9227-6
- Hambrick, D.Z., & Engle, R.W. (2002). Effects of domain knowledge, working memory capacity, and age on cognitive performance: An investigation of the knowledge-is-power hypothesis. *Cognitive Psychology, 44*, 339-387. doi: 10.1006/cogp.2001.0769
- Hand, B., Alvermann, D., Gee, J., Guzzetti, B., Norris, S., Phillips, L., Prain, V., & Yore, L. (2003). What is literacy in science literacy? *Journal of Research in Science Teaching, 40*(7), 607–615.
- Hansen, K.A., Hillenbrand, S.F., & Ungerleider, L.G. (2012). Human brain activity predicts individual differences in prior knowledge use during decisions. *Journal of Cognitive Neuroscience, 24*(6), 1462-1475.
- Hargittai, E., & Shafer, S. (2005). Differences in actual and perceived online skills: The role of gender. *Social Science Quarterly, 87*(2), 432-448.
- Hart, S.A., Soden, B., Johnson, W., Schatschneider, C., & Taylor, J. (2013). Expanding the environment: gene x school-level SES interaction on reading comprehension. *Journal of Child Psychology and Psychiatry, 54*(10), 1047-1055. doi: 10.1111/jcpp.12083
- Henry, L.A. (2006). SEARCHing for an answer: The critical role of new literacies while reading on the Internet. *Reading Teacher, 59*(7), 614-627.
- Ho, H.N.J., Tsai, M-J., Wang, C-Y., & Tsai, C-C. (2014). Prior knowledge and online inquiry-based science reading: Evidence from eye tracking. *International Journal of Science and Mathematics Education, 12*, 525-554.

- Hogan, N., & Vernhagen, C. (2012). Critical appraisal of information on the Web in practice: Undergraduate students' knowledge, reported use, and behavior. *Canadian Journal of Learning and Technology*, 38(1), 1-14.
- Horrigan, J. (2006). The Internet as a resource for news and information about science. Pew Internet and American Life Project. Retrieved from www.pewinternet.org/Reports/2006/The-Internet-as-a-Resource-for-News-and-Information-about-Science/01-Summary-of-Findings.aspx.
- Hoxby, C. (2000). Peer effects in the classroom: Learning from gender and race variation. National Bureau of Economic Research Working Paper 7867.
- Hoxby, C. M., & Weingarth, G. (2007). Taking race out of the equation: School reassignment and the structure of peer effects. *Education*, 18, 2005.
- Jackson, L.A., Ervin, K. S., Gardner, P.D., & Schmitt, N. (2001). Gender and the Internet: Women communicating and men searching. *Sex roles*, 44(5-6), 363-379.
- Jacob, B.A. (2002). Where the boys aren't: Non-cognitive skills, returns to school and the gender gap in higher education. *Economics of Education Review*, 21(6), 589-598.
- Jenkins, H. (2006). *Convergence Culture: Where Old and New Media Collide*. New York: New York University Press.
- Jiménez-Aleixandre, M., & Pereiro-Muñoz, C. (2002). Knowledge producers or knowledge consumers? Argument and decision making about environmental management. *International Journal of Science Education*, 24(11), 1171-1190.
- Jonassen, D.H., & Grabowski, B.L. (2012). *Handbook of Individual Differences: Learning and Instruction*. New York, New York: Routledge.

- Jones, L., G., Wheeler, & Centurino, A.S. (2013). TIMSS 2015 science framework. In I.V.S. Mullis & M.O. Martin (Eds.), *TIMSS 2015 assessment frameworks* (pp. 29-58). Retrieved from <http://timssandpirls.bc.edu/timss2015/frameworks.html>
- Judd, V.C., Farrow, L.I. and Tims, B.J. 2006. Evaluating public web site information: a process and an instrument. *Reference Service Review*, Vol. 34, No. 1, pp. 12-32.
- Kali, Y., & Linn, M. C. (2008). Designing effective visualizations for elementary school science. *The Elementary School Journal*, 109, 181–198. doi: 10.1086/590525
- Kamil, M.L., Pearson, P.D., Moje, E.B., & Afflerbach, P. (2011). *Handbook of Reading Research*, Volume IV. New York: Routledge.
- Kang, H., & Lundeberg, M.A. (2010). Participation in science practices while working in a multimedia case-based environment. *Journal of Research in Science Teaching*, 47 (9), 1116-1136.
- Katz, S., Allbritton, D., Aronis, J., Wilson, C., & Soffa, M. L. (2006). Gender, achievement, and persistence in an undergraduate computer science program. *The Database for Advances in Information Systems*, 37, 42–57.
- Kendeou, P., & van den Broek, P. (2007). The effects of prior knowledge and text structure on comprehension processes during reading of scientific texts. *Memory & Cognition*, 7, 1567-1577.
- Kennedy, C., Rhoads, C., and Leu, D.J. (2016). Online research and learning in science: A one-to-one laptop comparison in two states using performance based assessments. *Computers & Education*, 100, 1-21.

- Kieffer, M.J. (2012). Before and after third grade: Longitudinal evidence for the shifting role of socioeconomic status in reading growth. *Reading and Writing: An Interdisciplinary Journal*, 25(7), 1725-1746.
- Kiili, C., Laurinen, L., & Marttunen, M. (2008). Students evaluating Internet sources: From versatile evaluators to uncritical readers. *Journal of Educational Computing Research*, 39(1), 75–95. Retrieved from <http://www.editlib.org/p/69326/>
- Kiili, C., Laurinen, L., & Marttunen, M. (2009). Skillful Internet reader is metacognitively competent. In L. T. W. Hin & R. Subramaniam (Eds.) *Handbook of Research on New Media Literacy at the K-12 Level: Issues and Challenges* (pp. 654–668). Hershey, PA: IGI Global.
- Kiili, C., Laurinen, L., Marttunen, M., & Leu, D. (2012). Working on understanding during collaborative online reading. *Journal of Literacy Research*, 44(4), 448-483.
- Kim, D. Y., Lehto, X. Y., & Morrison, A. M. (2007). Gender differences in online travel information search: Implications for marketing communications on the internet. *Tourism Management*, 28(2), 423-433.
- Kingsley, T., & Tancock, S. (2014). Internet inquiry: Fundamental competencies for online comprehension. *The Reading Teacher*, 67(5), 389–399. doi: 10.1002/trtr.1223
- Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York, NY: Cambridge University Press.
- Kintsch, W. (2013). Revisiting the construction-integration model of text comprehension and its implications for instruction. In D. Alvermann, N. Unrau, & R. Ruddell (Eds.), *Theoretical models and processes of reading* (pp. 807-841). Newark, DE: International Reading Association.

- Kintsch, W., Patel, V.L., & Ericsson, K.A. (1999). The role of long-term working memory in text comprehension. *Psychologia*, 42(4), 186-198.
- Kobayashi, K. (2014). Students' consideration of source information during the reading of multiple texts and its effect on intertextual conflict resolution. *Instructional Science*, 42(2), 183-205. doi: 10.1007/s11251-013-9276-3
- Koohang, A., & Durante, A. (2003). Learners' perceptions toward the web-based distance learning activities/assignments portion of an undergraduate hybrid instructional model. *Journal of Information Technology Education: Research*, 2(1), 105-113.
- Krajcik, J.S., & Sutherland, L.M. (2010). Supporting students in developing literacy in science. *Science*, 328, 456-459.
- Kuiper, E., & Volman, M. (2008). The Web as a source of information for students in K–12 education. In J. Coiro, M. Knobel, C. Lankshear, & D. Leu (Eds.), *Handbook of research on new literacies* (pp. 241–246). Mahwah, NJ: Lawrence Erlbaum.
- Kush, J.C., & Watkins, M.W. (1996). Long-term stability of children's attitudes toward reading. *The Journal of Educational Research*, 89(5), 315–319. doi:10.1080/00220671.1996.9941333
- Labbo, L. & Reinking, D. (1999). Negotiating the multiple realities of technology in literacy research and instruction. *Reading Research Quarterly*, 34(4), 478-492. doi: 10.1598/RRQ.34.4.5
- Langer, J. (2011). *Envisioning literature, second edition*. Newark: DE: International Reading Association.
- Lavy, V., Paserman, M.D., & Schlosser, A. (2008). Inside the black box of peer effects: Evidence from variation in the proportion of low achievers in the classroom.

- Lavy, V. & Schlosser, A. (2011). Mechanisms and Impacts of Gender Peer Effects at School. *American Economic Journal: Applied Economics*, 3, 1-33.
- Le Bigot, L., & Rouet, J.F. (2007). The impact of presentation format, task assignment, and prior knowledge on students' comprehension of multiple online documents. *Journal of Literacy Research*, 39(4), 445-470.
- Lees, L. H. 1994. Educational inequality and academic achievement in England and France. *Comparative Education Review* 38:65-87.
- Lemke, J. (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J. Martin & R. Veel (Eds.), *Reading science: Critical and functional perspectives on discourses of science* (pp. 87-113). London: Routledge.
- Lenhart, A., Simon, M., & Graziano, M. (2001, September). *The Internet and education: Findings of the Pew Internet & American life project*. Washington, DC: Pew Internet & American Life Project. Retrieved from http://www.pewinternet.org/files/old-media/Files/Reports/2001/PIP_Schools_Report.pdf.pdf
- Lepola, J., Salonen, P., & Vauras, M. (2000). The development of motivational orientations as a function of divergent reading careers from pre-school to the second grade. *Learning and Instruction*, 10, 153–177.
- Letts, W. (2001). When science is strangely alluring: Interrogating the masculinist and heteronormative nature of primary school science. *Gender and Education*, 13, 261–274.
- Leu, D.J. (2000). Literacy and technology: Deictic consequences for literacy education in an information age. In M.L. Kamil, P.B. Mosenthal, P.D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. 3, pp. 743-770). Mahwah, NJ: Lawrence Erlbaum Associates.

- Leu, D.J., Castek, J., & Hartman, D. (2006). Evaluating the development of scientific knowledge and new forms of reading comprehension during online learning. Retrieved from www.newliteracies.uconn.edu/ncrel_files/FinalNCRELReport.pdf
- Leu, D.J., Castek, J., Hartman, D., Coiro, J., Henry, L., Kulikowich, J., & Lyver, S. (2005). *Evaluating the development of scientific knowledge and new forms of reading comprehension during online learning*. Final report presented to the North Central Regional Educational Laboratory/Learning Point Associates.
- Leu, D. J., Forzani, E., Rhoads, C., Maykel, C., Kennedy, C., & Timbrell, N. (2015). The new literacies of online research and comprehension: Rethinking the reading achievement gap. *Reading Research Quarterly*, 50(1). doi: 10.1002/rrq.85. Retrieved from [http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)1936-2722/earlyview](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1936-2722/earlyview)
- Leu, D.J., Kiili, C., & Forzani, E. (2015). Individual differences in the new literacies of online research and comprehension. To appear in: Afflerbach, P. (Ed.) *Handbook of Individual Differences in Reading: Reader, Text, and Context*. New York: Routledge.
- Leu, D.J., Jr., Kinzer, C.K. Coiro, J., Cammack, D. (2004). Toward a theory of new literacies emerging from the Internet and other information and communication technologies. In R.B. Ruddell & N. Unrau (Eds.), *Theoretical Models and Processes of Reading, Fifth Edition* (1568-1611). International Reading Association: Newark, DE.
- Leu, D. J., Kinzer, C. K., Coiro, J., Castek, J., Henry, L. A. (2013). New literacies: A dual level theory of the changing nature of literacy, instruction, and assessment. In Alvermann, D. E., Unrau, N. J., & Ruddell, R. B. (Eds.), *Theoretical Models and Processes of Reading, Sixth Edition*. Newark, DE: International Reading Association.

- Leu, D.J., Kulikowich, J., Sedransk, N., & Coiro, J. (2009–2014). Assessing online reading comprehension: The ORCA Project. Washington, DC: Institute of Education Sciences, U.S. Department of Education.
- Leu, D.J., Kulikowich, J.M., Sedransk, N., Coiro, J., Liu, C., Cui, W., Forzani, E., Kennedy, C., & Maykel, C. (2014, April). The ORCA Project: Designing technology-based assessments for online research, comprehension, and communication. Paper presented at the annual meeting of the American Educational Research Association, Philadelphia, PA.
- Leu, D.J., McVerry, J.G., O’Byrne, W.I., Kiili, C., Zawilinski, L., Everett-Cacopardo, H., . . . , Forzani, E. (2011). The new literacies of online reading comprehension: Expanding the literacy and learning curriculum. *Journal of Adolescent & Adult Literacy*, 55(1), 5-14.
doi: 10.1598/JAAL.55.1.1
- Leu, D.J., Zawilinski, L., Castek, J., Banerjee, M., Housand, B.C., Liu, Y., & O’Neil, M. (2007). What is new about the new literacies of online reading comprehension? In L.S. Rush, A.J. Eakle & A. Berger (Eds.), *Secondary school literacy: What research reveals for classroom practice* (pp. 37 – 68). Urbana, IL: National Council of Teachers of English. Retrieved from www.newliteracies.uconn.edu/docs/whats%20new%20about%20online%20reading%20comprehension.pdf
- Leu, D.J., Zawilinski, L., Forzani, E., & Timbrell, N. (2015). Best practices in teaching the new literacies of online research and comprehension. In L.B. Gambrell and L.M. Morrow (Eds.), *Best Practices in Literacy Instruction, Fifth Edition* (pp. 343-364). New York, NY: The Guilford Press.
- Liberman, I. Y., Shankweiler, D., & Liberman, A. M. (1989). The alphabetic principle and learning to read. In D. S. I. Y. Liberman (Ed.), *Phonology and reading disability: Solving*

- the reading puzzle. Research Monograph Series. Ann Arbor, MI: University of Michigan Press.
- Lipson, M.Y. (1982). Learning new information from text: The role of prior knowledge and reading ability. *Journal of Reading Behavior*, 14, 243-261.
- Liu, Z. M., & Huang, X. B. (2008). Gender differences in the online reading environment. *Journal of Documentation*, 64(4), 616-626.
- Livingstone, M. S., Rosen, G. D., Drislane, F.W., & Galaburda, A. M. (1991). Physiological and anatomical evidence for a magnocellular defect in developmental dyslexia. Proceedings of the National Academy of Science USA, 88, 7943–7947.
- Logan, S., & Johnston, R. (2010). Investigating gender differences in reading. *Educational Review*, 62(2), 175-187.
- Long, D.L., Oppy, B.J., & Seely, M.R. (1994). Individual differences in the time course of inferential processing. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 20, 1456-1470.
- Longino, H.E. (2002). *The fate of knowledge*. Princeton, NJ: Princeton University Press.
- Loveless, T. (2015). How well are American students learning? The 2015 Brown Center Report on American Education. Brown Center on Education Policy at Brookings. The Brookings Institute.
- Ma, X., & Wilkins, J.L.M. (2002). The development of science achievement in middle and high school: Individual differences and school effects. *Evaluation Review*, 26(4), 395-417.
- Macedo-Rouet, M., Braasch, J.L.G., Britt, M.A., & Rouet, J. (2013). Teaching fourth and fifth graders to evaluate information sources during text comprehension. *Cognition & Instruction*, 31(2), 204-226. doi: 10.1080/07370008.2013.769995

- Manderino, M. (2012). Reading digitally like a historian: Using multimedia texts to facilitate disciplinary learning. *The Connecticut Reading Association Journal*, 1, 79-82.
- Martin, M.O., Mullis, I.V.S., Foy, P., & Stanco, G.M. (2012). *TIMSS 2011 International Results in Science*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.
- Martin, J.R. (1993). Life as a noun: Arresting the universe in science and humanities. In M.A.K. Halliday & J.R. Martin (Eds.), *Writing science: Literacy and discursive power* (pp. 221-267). Pittsburg, PA: University of Pittsburg Press.
- McDonald, S., & Stevenson, R.J. (1996). Disorientation in hypertext: The effects of three text structures on navigation performance. *Applied Ergonomics*, 27(1), p. 61-68).
- McLaughlin, M., & DeVogd, G. (2003). Critical literacy as comprehension: Expanding reader response. *Journal of Adolescent and Adult Literacy*, 48, 52-62.
- McNamara, D.S., & Kintsch, W. (1996). Learning from text: Effects of prior knowledge and text coherence. *Discourse Processes*, 22 (3), 247-288. doi: 10.1080/01638539609544975
- McVerry, G. (2013). The Internet and adolescent readers: Exploring relationships between online reading comprehension, prior knowledge, critical evaluation, and dispositions (Doctoral dissertation). University of Connecticut, Storrs, CT.
- Means, M. L., & Voss, J. F. (1996). Who reasons well?: Two studies of informal reasoning among children of different grade, ability, and knowledge levels. *Cognition and Instruction*, 14, 129-178.
- Merzenich, M. M., Jenkins, W. M., Johnston, P., Schreiner, C., Miller, S. L., & Tallal, P. (1996). Temporal processing deficits of language-learning impaired children ameliorated by training. *Science*, 271, 77–81.

- Millar, R. (2006). Twenty First Century Science: Insights from the design and implementation of a scientific literacy approach in school science. *International Journal of Science Education*, 28(13), 1499-1521.
- Miller, C., & Bartlett, J. (2012). 'Digital fluency': Towards young people's critical use of the Internet. *Journal of Information Literacy*, 6(2), 35-55. Doi: 10.11645/6.2.1714
- Miller, P. H., Blessing, J. S., & Schwartz, S. (2006). Gender differences in high school students' views about science. *International Journal of Science Education*, 28, 363–381.
- Miller, L. S., Cohen, J., & Wingfield, A. (2006). Contextual knowledge reduces demands on working memory during reading. *Memory & Cognition*, 34, 1355–1367.
- Morahan-Martin, J. M. (2004). How internet users find, evaluate, and use online health information: A cross-cultural review. *CyberPsychology & Behavior*, 7, 497–510. doi:10.1089/cpb.2004.7.497
- Moss, G. (2000). Raising boys' attainment in reading: Some principles for intervention. *Reading*, 34(3), 101–106.
- Mullis, I.V.S., & Martin, M.O. (Eds.). (2015). *PIRLS 2016 assessment framework, 2nd Edition*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College. Retrieved from timssandpirls.bc.edu/pirls2016/framework.html
- Mullis, I.V.S., Martin, M.O., Foy, P., & Drucker, K.T. (2012). *PIRLS 2011 International Results in Reading*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College. Retrieved from <http://timssandpirls.bc.edu/pirls2011/international-results-pirls.html>

- Mullis, I.V.S., Martin, M.O., Foy, P., & Stanco, G.M. (2012). *TIMSS 2011 International Results in Science*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College. Retrieved from <http://timssandpirls.bc.edu/timss2011/international-database.html>
- Mundform, D.J., Perrett, J.J., Schaffer, J., Piccone, A., & Roozeboom, M. (2006). Bonferroni adjustments in tests for regression coefficients. *Multiple Linear Regression Viewpoints*, 32(1), 1-6.
- National Academy of Sciences. *Rising above the gathering storm: Energizing and employing American for a brighter future*. (2005). Washington, DC: National Academies Press.
- National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2011). *Rising above the gathering storm revisited: Rapidly approaching category 5*. Condensed version. Washington, DC: The National Academies Press.
- National Assessment Governing Board [N.A.G.B.], U.S. Department of Education. (2010). Science Framework for the 2011 National Assessment of Educational Progress. Retrieved from <http://nces.ed.gov/nationsreportcard/science/whatmeasure.aspx>
- National Center for Education Statistics. (2011b). The Nation's Report Card: Reading 2011 (NCES 2012-457). Washington, DC : Institute of Education Sciences, U.S. Department of Education . Retrieved from nces.ed.gov/nationsreportcard/pdf/main2011/2012457.pdf
- National Center for Education Statistics. (2013). *The Nation's Report Card: A first look: 2013 mathematics and reading (NCES 2014-451)*. Washington, DC: Institute of Education Sciences, U.S. Department of Education. Retrieved from nces.ed.gov/nationsreportcard/subject/publications/main2013/pdf/2014451.pdf
- National Governors Association Center for Best Practices, Council of Chief State School Officers (2010). *Common Core State Standards for English language arts and literacy in*

history/social studies, science, and technical subjects. Washington, D.C.

National Governors Association Center for Best Practices, Council of Chief State School

Officers (CCSSO). (2016). Common Core State Standards' *English Language Arts Key Design Considerations*. Retrieved from

<http://www.corestandards.org/ELA-Literacy/introduction/key-design-consideration/>

National Research Council (NRC). (2007). *Taking science to school:*

Learning and teaching science in grades K-8. Washington, DC: The National

Academies Press. The President's Council of Advisors on Science and Technology, 2010.

National Research Council (NRC). (2005). America's lab report: Investigations in high school science. Washington, DC: National Academies Press.

National Research Council (NRC). (2008). Ready, set, science: Putting research to work in K–8 science classrooms. Washington, DC: National Academies Press.

National Research Council (NRC). (2012). A Framework for K–12 Science Education: Practices, Crosscutting Concepts and Core Ideas. Washington: National Academies Press.

National Science Board (2003). *The science and engineering workforce: Realizing America's potential, NSF03-69*. Arlington, VA: National Science Foundation.

National Science Foundation (2014). National Center for Science and Engineering Statistics.

Survey of earned doctorates. Doctorate recipients from U.S. Universities: 2014. Retrieved from <http://www.nsf.gov/statistics/2016/nsf16300/data-tables.cfm>

National Science Foundation. (2015). National Center for Science and Engineering Statistics.

Women, Minorities, and Persons with Disabilities in Science and Engineering. Table 9-5.

Employed scientists and engineers, by occupation, highest degree level, and sex: 2013.

Retrieved from <http://www.nsf.gov/statistics/2015/nsf15311/tables.cfm>

- National Science and Technology Council. (2013). *Federal science, technology, engineering, and mathematics (STEM) education 5-year strategic plan*. Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf
- Newell, A., & Simon, H.A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice Hall.
- Newkirk, T. (2006). With boys in mind/Media and literacy: What's good? *Educational Leadership*, 64(1), 62 – 66.
- NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC. The National Academies Press. Retrieved from <http://www.nextgenscience.org/next-generation-science-standards>
- Nicholson, L.M., Slater, S.J., Chriqui, J.F., & Chaloupka, F. (2014). Validating adolescent socioeconomic status: Comparing school free or reduced price lunch with community measures. *Spatial Demography*, 2(1), 55-65.
- Norris, S. P., & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education*, 87, 224–240.
- Oakhill, J.V. (1984). Inferential and memory skills in children's comprehension of stories. *British Journal of Educational Psychology*, 54, 31-39.
- Obama, President B. (2015). *Remarks by the President at White House Science Fair*. The White House. Office of the Press Secretary. Retrieved from <https://www.whitehouse.gov/the-press-office/2015/03/23/remarks-president-white-house-science-fair>
- O'Byrne, I. (2012). Facilitating critical evaluation skills through content creation: Empowering adolescents as readers and writers of online information. (Doctoral dissertation). University of Connecticut, Storrs, CT.

- O'Reilly, T., & McNamara, D.S. (2007). Reversing the reverse cohesion effect: Good texts can be better for strategic, high-knowledge readers. *Discourse Processes*, 43(2), 121-152.
- Organisation for Economic Co-operation and Development; Programme for International Student Assessment [O.E.C.D.] (2010). Students on line: reading and using digital information. OECD: Paris.
- Organisation for Economic Co-operation and Development & the Centre for Educational Research and Innovation [O.E.C.D.]. (2010). *Trends shaping education 2010*. Paris: OECD Publishing.
- Organisation for Economic Co-operation and Development [OECD]. (2011). *PISA 2009 results: Students on line: Digital technologies and performance (Volume VI)*, Paris, France: Author. Doi: 10.1787/9789264112995-en
- Organisation for Economic Co-operation and Development [OECD]. (2013, March). *PISA 2015 Draft Science Framework*. Retrieved from <https://www.oecd.org/pisa/pisaproducts/pisa2015draftframeworks.htm>
- Organisation for Economic Cooperation and Development [OECD]. 2015. The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence. PISA, OECD Publishing. Retrieved from <http://dx.doi.org/10.1787/9789264229945-en>
- Osborne, J. (2002). Science without literacy: A ship without a sail? *Cambridge Journal of Education*, 32, 203–218.
- Ozuru, Y., Best, R., Bell, C., Witherspoon, A., & McNamara, D. S. (2007). Influence of question format and text availability on the assessment of expository text comprehension. *Cognition and Instruction*, 25, 399–438.
- Ozuro, Dempsey, & McNamara, 2009. Prior knowledge, reading skill, and text cohesion in the

- comprehension of science texts. *Learning and Instruction*, 19, 228-242.
- Pearson, P.D., Hansen, J., & Gordon, C. (1979). The effect of background knowledge on young children's comprehension of explicit and implicit information. *Journal of Reading Behavior*, XI, 201-209.
- Pearson, P.D., Moje, E.B., & Greenleaf, C. (2010). Literacy and science: Each in service of the other. *Science*, 328, 459-463.
- Peeck, J., van den Bosch, A.B., & Kreupeling, W.J. (1982). Effect of mobilizing prior knowledge on learning from text. *Journal of Educational Psychology*, 74, 771-777.
- Perfetti, C. (2011). Phonology is critical in reading but a phonological deficit is not the only source of low reading skill. In S.A. Brady, D. Braze, & C.A. Fowler (Eds.), *Explaining individual differences in reading* (pp.153-171). New York: Psychology Press.
- PIAAC Expert Group on Problem Solving in Technology-Rich Environments. (2009). *PIAAC problem solving in technology-rich environments: A conceptual framework* (OECD Education Working Paper No. 36). Paris, France: OECD. Doi: 10.1787/220262483674 Retrieved from [http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=edu/wkp\(2009\)15](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=edu/wkp(2009)15)
- Porter, J.A., Wolbach, K.C., Purzycki, C.B., Bowman, L.A., Agbada, E. & Mostrom, A.M. (2010). Integration of information and scientific literacy: promoting literacy in undergraduates. *CBE Life Sciences Education*, 9, 536–542.
- The President's Council of Advisors on Science and Technology. (2010, September). *Prepare and Inspire: K12 Education in STEM for America's Future*. Retrieved November 2, 2011, from The White House:

<http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast--stemed--report.pdf>

Pressley, M., & Afflerbach, P. (1995). *Verbal protocols for reading: The nature of constructively responsive reading*. Hillsdale, NJ: Lawrence Erlbaum.

Pressley, M. & Gaskins, I. (2006). Metacognitively competent reading comprehension is constructively responsive reading: How can such reading be developed in students? *Metacognition Learning*, 1(1), 99-113.

Protopapas, G. D., Sideridis, P. G., Simos, G., & Mouzaki, A. (2007). The development of lexical mediation in the relationship between text comprehension and word reading skills in Greek. *Scientific Studies of Reading*, 11(3), 165–197.

Quintana, C., Zhang, M., & Krajcik, J. 2005. A Framework for Supporting Metacognitive Aspects of Online Inquiry Through Software-based Scaffolding. *Educational Psychologist* 40: 235-244.

RAND Reading Study Group. (2002). *Reading for understanding: Toward an R&D program in reading comprehension*. Santa Monica, CA: RAND. Retrieved from <http://www.dsusd.k12.ca.us/users/christopherg/reading%20program%20for%20teachers.pdf>

Rapp, D. & van den Broek, P. (2005). Dynamic text comprehension: An integrative view of reading. *Current Directions in Psychological Science*, 14(5), 276-279.

Reardon, S.F. (2013). The widening income achievement gap. *Educational Leadership*, 70(8), 10-16.

- Reiegle-Crumb, C., & King, B. (2010). Questioning a white male advantage in STEM: Examining disparities in college major by gender and race/ethnicity. *Educational Researcher*, 39(9), 656-664.
- Rieh, S. Y., & Belkin, N. J. (1998). Understanding judgment of information quality and cognitive authority in WWW. *Journal of the American Society for Information Science*, 35, 279-289.
- Rouet, J-F., Ros, C., Goumi, A., Macedo-Rouet, M., & Dinet, J. (2011). The influence of surface and deep cues on primary and secondary school students' assessment of relevance in Web menus. *Learning and Instruction*, 21(2), 205-219. doi:10.1016/j.learninstruc.2010.02.007
- Sabatini, J., O'Reilly, T., Halderman, L.K., & Bruce, K.M. (2014, April). *Developing theory-based literacy assessments for pre-K-12 students: Challenges and opportunities*. Paper presented at the annual meeting of the American Educational Research Association, Philadelphia, PA.
- Salonen, P., Lepola, J., & Niemi, P. (1998). The development of first graders' reading skill as a function of pre-school motivational orientation and phonemic awareness. *European Journal of Psychology of Education*, 13, 155-174.
- Sanchez, C. A., Wiley, J., & Goldman, S. R. (2006). Teaching students to evaluate source reliability during Internet research tasks. In S. A. Barab, K. E. Hay, & D. T. Hickey (Eds.), *Proceedings of the seventh international conference on the learning sciences* (pp. 662-666). Bloomington, IN: International Society of the Learning Sciences.
- Saul, E.W. (2004). *Crossing borders in literacy and science instruction: Perspectives on theory into practice*. Newark, DE: International Reading Association.

- Scanlon, D. M., & Vellutino, F. R. (1997). A comparison of the instructional backgrounds and cognitive profiles of poor, average, and good readers who were initially identified as at risk for reading failure. *Scientific Studies of Reading*, 1(3), 191–215.
- Scharrer, L., Stadtler, M., & Bromme, R. (2014). You'd better ask an expert: Mitigating the comprehensibility effect on laypeople's decisions about science-based knowledge claims. *Applied Cognitive Psychology*, 28, 465-471. Doi: 10.11002/acp.3018.
- Schumacher, P., & Morahan-Martin, J. (2001). Gender, Internet and computer attitudes and experiences. *Computers in human behavior*, 17(1), 95-110.
- Schwabe, F., & McElvany, N. (2014). The school age gender gap in reading achievement: Examining the influences of item format and intrinsic reading motivation. *Reading Research Quarterly*, 50(2), 219-232.
- Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. *Harvard Educational Review*, 78, 40-59. Retrieved from <http://hepg.org/>
- Shanahan, C., Shanahan, T., & Misischia, C. (2011). Analysis of expert readers in three disciplines: History, Mathematics, and Chemistry. *Journal of Literacy Research*, 43, 393-429.
- Shankweiler, D., & Crain, S. (1986) Language mechanisms and reading disorder: A modular approach. *Cognition*, 24, 139–168.
- Shankweiler, D., Crain, S., Katz, L., Fowler, A. E., Liberman, A. M., Brady, S. A., et al. (1995). Cognitive profiles of reading-disabled children: Comparison of language skills in phonology, morphology, and syntax. *Psychological Science*, 6, 149–156.

- Shany, M., & Biemiller, A. (2010). Individual differences in reading comprehension gains from assisted reading practice: pre existing conditions, vocabulary acquisition, and amounts of practice. *Reading and Writing*, 23, 1071-1083. doi: 10.1007/s11145-009-9196-4
- Individual
- Sirin, S. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research*, 75(3), 417-453.
- Smarter Balanced Assessment Consortium. (2015). Smarter balanced assessments. Retrieved from <http://www.smarterbalanced.org/smarter-balanced-assessments/>
- Smith, M.W., & Wilhelm, J.D. (2006). *Going with the flow: How to engage boys (and girls) in their literacy learning*. Portsmouth, NH: Heinemann.
- Sormunen, E., & Pennanen, S. (2004). The challenge of automated tutoring in Web-based learning environments for information retrieval instruction. *Information Research – An International Electronic Journal*, 9(2).
- Stadtler, M., & Bromme, R. (2014). The content-source integration model: A taxonomic description of how readers comprehend conflicting scientific information. In D.N. Rapp & J. Braasch (Eds.), *Processing inaccurate information: Theoretical and applied perspectives from cognitive science and the educational sciences* (p 379-402). Cambridge, MA: MIT Press.
- Stadtler, M., Scharrer, L., Macedo-Rouet, M., Rouet, J-F., & Bromme, R. (2016). Improving vocational students' consideration of source information when deciding about science controversies. *Read Writ*, 29, 705-729. Doi: 10.1007/s11145-016-9623-2

- Stake, J. E. (2006). The critical mediating role of social encouragement for science motivation and confidence among high school girls and boys. *Journal of Applied Social Psychology*, 36, 1017–1045.
- Stein, J., & Walsh, V. (1997). To see but not to read; the magnocellular theory of dyslexia. *Trends Neuroscience*, 20, 147–152.
- Strømsø, H.L., Bråten, I., Britt, M.A., & Ferguson, L.E. (2013). Spontaneous sourcing among students reading multiple documents. *Cognition and Instruction*, 31(2), 176-203.
doi:10.1080/0737008.2013.769994
- Surber, J. R., & Schroeder, M. (2007). Effect of prior domain knowledge and headings on processing of informative text. *Contemporary Educational Psychology*, 32, 485–498.
- Sutherland-Smith, W. (2002). Weaving the literacy Web: Changes in reading from page to screen. *The Reading Teacher*, 55(7), 662-669.
- Tabachnick & Fidell (2013). Using multivariate statistics (6th ed). Boston, MA: Pearson.
- Tabak, I. (2015). Functional scientific literacy: Seeing the science within the words and across the web. In L. Corno & E.M. Anderman (Eds.), *Handbook of educational psychology* (3rd ed., pp. 269-280). London: Routledge.
- Taboada, A., & Guthrie, J. (2006). Contributions of student questioning and prior knowledge to construction of knowledge from reading information text. *Journal of Literacy Research*, 38, 1–35.
- Tang, W., Cui, Y., & Babenko, O. (2014). Internal consistency: Do we really know what it is and how to assess it? *Journal of Psychology and Behavioral Science*, 2(2), 205-220.

- Theisens, H., Roberts, K., & Istance, D. (2010). *Trends shaping education 2010*. Paris, France: Organisation for Economic Co-operation and Development & the Centre for Educational Research and Innovation.
- Thiers, N. (2006). Do single-sex classes raise academic achievement? *Educational Leadership*, 63(7), 70.
- Thoman, E., & Jolls, T. (2005). *Literacy for the 21st century: An overview and orientation guide to media literacy education. Part I: Theory*. Santa Monica, CA: Center for Media Literacy. Retrieved from <http://medialit.org/cml-medialit-kit>
- Thomm, E., & Bromme, R. (2016). How source information shapes lay interpretation of science conflicts: interplay between sourcing, conflict explanation, source evaluation, and claim evaluation. *Read Writ*. doi:10.1007/s11145-106-9638-8
- Tobin, R. & McInnes, A. (2008). Accommodating differences: Variations in differentiated literacy instruction in Grade 2/3 classrooms. *Literacy*, 42(1), 3–9.
- Toulmin, S., Rieke, R., and Janik, A. (1984). *An introduction to reasoning, second edition*. Macmillan.
- Tsai, M.-J., Hsu, C.-Y. & Tsai, C.-C. (2012). Investigation of high school students' online searching performance: The role of implicit and explicit approaches. *Journal of Science Education and Technology*, 21(2), 246–254.
- Unsworth, L. (1999). Developing critical understanding of the specialized language of school science and history texts: A functional grammatical perspective. *Journal of Adolescent and Adult Literacy*, 42, 508–521.
- U.S. Department of Agriculture, Food and Nutrition Service. (2013). Child Nutrition Programs; Income Eligibility Guidelines. Retrieved from <http://www.fns.usda.gov/school->

meals/income-eligibility-guidelines

U.S. Department of Commerce, United States Census Bureau. (2015a). State and County Quick Facts. Retrieved from <http://quickfacts.census.gov/qfd/index.html>

U.S. Department of Commerce, United States Census Bureau . (2015b). State Median Income. Retrieved from <http://www.census.gov/hhes/www/income/data/statemedian/>

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. (2013). National Assessment of Educational Progress (NAEP), 2013 Reading Assessment. NAEP State Comparisons. Retrieved from <http://nces.ed.gov/nationsreportcard/statecomparisons/Default.aspx?usrSelections=1%2cRED%2c5%2c0%2cwithin%2c1%2c0>

U.S. Department of Education, National Center for Education Statistics. (2012). *Digest of Education Statistics*. Retrieved from <http://www2.ed.gov/about/overview/mission/mission.html?src=ln>

van Arensbergen, P., van der Weijden, I., & van den Besselaar, P. (2011). Gender differences in scientific productivity: A persistent phenomenon? *Scientometrics*, 93, 857-868. Doi: 10.1007/s11192-012-0712-y

Vardardottir, A. (2013). Peer effects and academic achievement: a regression discontinuity approach. *Economics of Education Review*, 36, 108-121.

van den Broek, P., & Kendeou, P. (2008). Cognitive processes in comprehension of science texts: The role of co-activation in confronting misconceptions. *Applied Cognitive Psychology*, 22, 335–351.

- Voss, J.F., Fincher-Kiefer, R.H., Greene, T.R., & Post, T.A. (1985). Individual differences in performance: The contrast approach to knowledge. In R.J. Sternberg (Ed.), *Advances in the psychology of human intelligence* (Vol 3, pp. 297-334). Hillsdale, NJ: Erlbaum.
- Voss, J.F., & Silfies, L.N. (1996). Learning from history text: The interaction of knowledge and comprehension skill with text structure. *Cognition and Instruction*, 14 (1), 45 – 68. doi: 10.1207/s1532690xcil401_2
- Wallace, R.M., Kupperman, J., Krajcik, J., & Solloway, E. (2000). Science on the Web: Students online in an sixth-grade classroom. *Journal of the Learning Sciences*, 9(1), 75-104. doi:10.1207/s15327809jls0901_5
- Walraven, A., Brand-Gruwel, S., & Boshuizen, H.P.A. (2009). How students evaluate information and sources when searching the World Wide Web for information.
- Webster, F. (2006). *Theories of the information society (third ed)*. Abingdon: Routledge. *Computers & Education*, 52(1), 234–246. doi:10.1016/j.compedu.2008.08.003
- Wigfield, A., Eccles, J. S., Yoon, K. S., Harold, R. D., Arbretton, A. J. A., Freedman-Doan, C., & Blumenfeld, P. C. (1997). Change in children's competence beliefs and subjective task values across the elementary school years: A 3-year study. *Journal of Educational Psychology*, 89, 451–469. doi:10.1037/0022-0663.89.3.451
- Wiley, J., Goldman, S., Graesser, A., Sanchez, C., Ash, I., & Hemmerich, J. (2009). Source evaluation, comprehension, and learning in Internet science inquiry tasks. *American Educational Research Journal*, 46, 1060–1106. doi:10.3102/0002831209333183
- Willis, G.B. (1999). Cognitive interviewing: A “how to” guide. Retrieved from appliedresearch.cancer.gov/areas/cognitive/interview.pdf

- Willoughby, T., Anderson, A., Wood, E., Mueller, J., & Ross, C. (2009). Fast searching for information on the Internet to use in a learning context: The impact of prior knowledge. *Computers & Education*, 52, 640-648.
- Wineburg, S.S. (1991). On the reading of historical texts: Notes on the breach between school and academy. *American Educational Research Journal*, 28, 495-519.
- Wright, T.S. (2013). From potential to reality: Content rich vocabulary and informational text. *Reading Teacher*, 57, (5), 359-367. doi: 10.1002/TRTR.1222
- Yang, Y. (2003). Dimensions of socio-economic status and their relationship to mathematics and science achievement at individual and collective levels. *Scandinavian Journal of Educational Research*, 47(1), 21-41.
- Yang, F-Y., Huang, R-T., & Tsai, I-J. (2016). The effects of epistemic beliefs in science and gender difference on university students' science-text reading: An eye-tracking study. *International Journal of Science and Mathematics Education*, 14, 473-498.
- Young, D. J., and B. J. Fraser. 1993. Socioeconomic and gender effects on science achievement: An Australian perspective. *School Effectiveness and School Improvement* 4:265-89.
- Yore, L.D. & Shymansky, J.A. (1991). Reading in science: Developing an operational conception to guide instruction. *Journal of Science Teacher Education*, 2(20), 29-36.
- Zeidler, D. (2009). Advancing reflective judgment through socioscientific issues. *Journal of Research in Science Teaching*, 46, 74–101. doi:10.1002/tea.20281
- Zhang, M. (2013). Supporting middle school students' online reading of scientific resources: Moving beyond cursory, fragmented, and opportunistic reading. *Journal of Computer Assisted Learning*, 29(2), 138 –152. doi :10.1111/j.1365-2729.2012.00478.x
- Zimmer, R. W., and E. F. Toma. 2000. "Peer Effects in Private and Public Schools across

Countries.” *Journal of Policy Analysis and Management*, 19, 75–92.

Zhang, S., & Duke, N.K. (2008). Strategies for Internet reading with different reading purposes: A descriptive study of twelve good Internet readers. *Journal of Literacy Research*, 40, 128-162.

APPENDICES

Appendix A. The Prior Knowledge Measures in the ORCA-II: Heart and Eyes

The Prior Knowledge Measure for the Heart Health Tasks

Welcome! What do you know about your heart? Answer each of the questions below about this topic. Click the "Submit" button when you are done.

1. The heart is an organ that belongs to which of the following systems?

- ☐ A. acoustic
- ☐ B. respiratory
- ☐ C. circulatory
- ☐ D. optic

2. The heart mainly:

- ☐ A. produces new blood
- ☐ B. mixes red and white blood cells
- ☐ C. holds blood in its chambers
- ☐ D. pumps blood throughout the body

3. The heart is composed mainly of:

- ☐ A. muscle and connective tissue
- ☐ B. muscle and cartilage
- ☐ C. bone and connective tissue
- ☐ D. cartilage and tendons

4. The heart works on a cycle that lasts .8 seconds. During each cycle, the heart:

4. The heart works on a cycle that lasts .8 seconds. During each cycle, the heart:

- ☐ A. continuously contracts and pumps blood to the rest of the body
- ☐ B. continuously pumps blood from the rest of the body into itself
- ☐ C. forces blood both in and out of the blood vessels
- ☐ D. forces blood into the blood vessels and also rests

5. A heart attack occurs when:

- ☐ A. The chambers of the heart receive the wrong kind of blood.
- ☐ B. Part of the heart is damaged due to blocked blood flow to the heart.
- ☐ C. Foods that you are trying to digest accidentally get caught in the heart's arteries.
- ☐ D. The lungs stop functioning.

6. High blood pressure is a condition in which:

- ☐ A. There is not enough blood flowing through the arteries.
- ☐ B. The force of oxygen flowing through the blood in the heart's chambers is too high.
- ☐ C. The pressure of the heart as it pumps blood to the lungs is too strong.
- ☐ D. The force of blood pushing against the walls of the arteries is too high.

7. How many chambers does the human heart have?

- ☐ A. one
- ☐ B. two
- ☐ C. four
- ☐ D. five

8. An increase in heart rate can be caused by:

- ☐ A. exercise
- ☐ B. deep breathing
- ☐ C. sleeping too much
- ☐ D. salty foods

9. The most common cause of heart disease is:

- ☐ A. an abnormal heartbeat
- ☐ B. a hardening of the arteries that restricts blood flow
- ☐ C. an enlarged left ventricle
- ☐ D. bacteria entering the bloodstream

10. The sound that is your heart beat is created when:

- ☐ A. Movement of blood speeds up and slows down and the heart vibrates.
- ☐ B. The heart moves from the left side to the right side of the body as it transfers blood.
- ☐ C. The arteries leading to the heart pump blood into the heart.
- ☐ D. The heart muscles contract as the heart receives blood from the lungs.

submit

The Prior Knowledge Measure for the Eye Health Task

Welcome! What do you know about your eyes? Answer each of the questions below about this topic. When you are finished click the "submit" button.

1. Our body has many systems. The eye is an organ that belongs to which of the following systems?

- ☐ A. optic
- ☐ B. circulatory
- ☐ C. acoustic
- ☐ D. respiratory

2. When the eye doctor says you have "20/20" vision, he/she means:

- ☐ A. You have perfect vision - you can see things correctly 20 out of 20 times.
- ☐ B. Your vision is only about 20% accurate.
- ☐ C. Your vision is "normal" - most people can see what you see at 20 feet.
- ☐ D. your vision is accurate 50% of the time - correct 20 times for every 20 times it is not correct.

3. Our eyes receive light waves through the_____.

- ☐ A. cornea
- ☐ B. retina
- ☐ C. optic nerve
- ☐ D. macula

4. This is a cloudy area that impairs vision and typically occurs in the eyes of elderly people:

- ☐ A. macular degeneration
- ☐ B. glaucoma
- ☐ C. conjunctivitis
- ☐ D. cataract

5. Nearsightedness is when:

- ☐ A. Distant objects appear clearly.
- ☐ B. Distant objects appear blurred.
- ☐ C. Near objects appear blurred.
- ☐ D. Near objects appear closer than they are.

6. What function does the lens of the eye serve?

- ☐ A. It is responsible for maintaining the shape of the eye.
- ☐ B. It bends or refracts light rays so that they focus on the nerves of the retina.
- ☐ C. Contact lenses help you to see better, and are often used instead of glasses.
- ☐ D. It helps your eye stay moist so it can function properly.

7. Binocular vision is_____.

- ☐ A. only achieved by looking through binoculars
- ☐ B. when only one eye is working properly
- ☐ C. when you see double
- ☐ D. when both eyes work together equally, as a team

8. The two most commonly found neurons in the retina are:

- ☐ A. rods and tones
- ☐ B. prods and cones
- ☐ C. rods and cones
- ☐ D. rods and phones

9. Night blindness is common of people suffering from a deficiency in this vitamin:

- ☐ A. vitamin B
- ☐ B. vitamin A
- ☐ C. vitamin C
- ☐ D. vitamin K

10. Astigmatism is an eye condition where_____.

- ☐ A. one eye is stronger than the other, resulting in headaches
- ☐ B. the two eyes do not focus together, causing dizziness
- ☐ C. the cornea is abnormally curved, causing vision problems
- ☐ D. the retina is misshapen, resulting in surgery

submit

Appendix B. The Critical Evaluation Webpages for the Four Science Tasks in the ORCAs

Figure 1. The Critical Evaluation Webpage for the Energy Drinks and Heart Health Task in the ORCAs

Page 1

http://www.MLBlogs.com/L1-54_filename2.html

Google Google Page 2 Coaches Corner Page 1 Page 1

MLBlogs Network Official Affiliate/Unofficial Opinions **MLB.com**

Performance Enhancing Drugs Can Ruin Your Life

Get the Facts about Health Risks from Steroids, Stimulants and HGH

Home | Get the Facts | Coaches Corner

Energy Drinks Are Popular But Are They Healthy?

While we all need an energy boost from time to time, an energy drink may not be the best way to get it, experts say. The FDA does not define the term "energy drink"; that label is up to manufacturers' discretion.

Teen athletes often turn to energy drinks for a boost during physical activity -- or for an added edge during competition. But be aware: Energy drinks are not designed to replace lost fluids during exercise. Rather than re-hydrating their bodies, these beverages may actually lead to dehydration.

There is also limited scientific evidence available that the consumption of these energy drinks can significantly improve physical and mental performance.

Most energy drinks contain high-tech-sounding ingredients that are not controlled substances, are of no value, and are potentially harmful in large amounts. For example, some energy drinks have between 150-500 milligrams of caffeine in 8 ounces. Unfortunately, the amount of caffeine is not often listed on the can. To provide a comparison on the caffeine content, 8 ounces of coffee has about 108 milligrams of caffeine, brewed tea has 50 milligrams and 12 ounces of coke has 34 milligrams. **Take a look at this chart** to find out the caffeine content in many popular energy drinks - and see the huge range that exists.

While we're not sure of the impact of large amounts of caffeine on the developing teen body, one thing is true - just like that morning cup of Joe, drinking energy drinks can be habit forming.

Energy drinks also contain plenty of calories from sugar, which can add up quickly if you drink a few cans. Aside from caffeine and sugar, some of the more common ingredients are ginseng, guarana, vitamins, and green tea. Trying to figure out exactly how much of each stimulant is contained in an energy drink can be difficult. The amount of the stimulants is not always listed on the label, and even when the information is listed, it is hard for consumers to interpret because we are not familiar with these ingredients.

Most people know how much caffeine they can tolerate, but may not be familiar with the effects of some of the other ingredients. Possible symptoms from drinking energy drinks include upset stomach, leg weakness, heart palpitations, nervousness, and more. If you drink these energy drinks on an empty stomach, the effects can be magnified. There will be an energy burst, but it could also lead to agitation, difficulty concentrating, hyperactivity, a problem sleeping, nausea, and increased blood pressure.

ABOUT DRUGFREMLBLOG



[Read about me](#)

RECENT ENTRIES

- ★ Little Leaguers: "I Won't Cheat"
- ★ Energy Drinks Are Popular But Are They Healthy?
- ★ Energy Drinks vs. Sports Drinks
- ★ Game Plan Your Breakfast
- ★ Nutritional Supplements for a 6th Grader?

RECENT COMMENTS

- ★ garyfalkenburg@msn.com on Little Leaguers: "I Won't Cheat"
- ★ garyfalkenburg@msn.com on Little Leaguers: "I Won't Cheat"
- ★ kingofcali on Game Plan Your Breakfast
- ★ eaglemoon@eaglemoonraes.com on Nutritional Supplements for a 6th Grader?

Coaches Corner: Energy Drinks Are Popular But Are They Healthy?

http://www.MLBlogs.com/L1-54_filename.html

coke has 34 milligrams. **Take a look at this chart** to find out the caffeine content in many popular energy drinks - and see the huge range that exists.

While we're not sure of the impact of large amounts of caffeine on the developing teen body, one thing is true - just like that morning cup of Joe, drinking energy drinks can be habit forming.

For more, listen to this related NPR story, **The Buzz on Energy Drinks**.

Tim Maxey

Head Strength and Conditioning Coordinator
Cleveland Indians Baseball

rated 4.0 by 1 person [?]

MLBlogs Network related articles

- [Coaches Corner: Game Plan Your Breakfast](#)
- [Coaches Corner: Little Leaguers: "I Won't Cheat"](#)
- [Coaches Corner: Nutritional Supplements for a 6th Grader?](#)
- [Coaches Corner: Energy Drinks vs. Sports Drinks](#)

Posted on June 2, 2009 at 11:21 AM

[Permalink](#) | [Comments \(0\)](#) [Report any abuse or spam](#)

[Read about me](#)

RECENT ENTRIES

- ★ Little Leaguers: "I Won't Cheat"
- ★ Energy Drinks Are Popular But Are They Healthy?
- ★ Energy Drinks vs. Sports Drinks
- ★ Game Plan Your Breakfast
- ★ Nutritional Supplements for a 6th Grader?

RECENT COMMENTS

- ★ garyfalkenburg@msn.com on Little Leaguers: "I Won't Cheat"
- ★ garyfalkenburg@msn.com on Little Leaguers: "I Won't Cheat"
- ★ kingofcali on Game Plan Your Breakfast
- ★ eaglemoon@eaglemoonraes.com on Nutritional Supplements for a 6th Grader?
- ★ indianslove on Game Plan Your

Figure 2. The Critical Evaluation Webpage for the Video Games and Eye Health Task in the ORCAs

Video Games and Vision - Video Games May Cause Vision Problems in Kids

http://www.About.com/L3-22_filename.html

Video Games Good forStudy: Video gamesStudy: Playing VideoVideo Games and VisionGoogleGoogle

Home > Health > Vision

Advertisement

Learn your risk factors and find out how a Retina Specialist can help at AMDAwareness.org

Genentech

ASRS
AMERICAN SOCIETY OF RETINA SPECIALISTS

About.com: Vision

VisionHealthy EyesEye ProblemsVision Correction

SEARCH

SharePrint

Playing Video Games May Cause Eyestrain

Encourage Safe Game Play Guidelines for Your Child

By Troy Bedinghaus, O.D., About.com Guide Updated February 19, 2008

About.com Health's Disease and Condition content is reviewed by the [Medical Review Board](#)

See More About:

[children's vision](#)

[computer vision syndrome](#)

Many parents wonder if spending too much time playing video games can hurt their child. Questions arise about obesity and aggressive behavior. While extended periods of time playing video games may possibly affect a child's weight and behavior, many parents often forget about the possible effects on their eyes and vision.

Playing video games for extended amounts of time can cause children to experience many of the same symptoms seen in [computer vision syndrome](#) in adults. Extensive viewing of the game screen can lead to eye discomfort, fatigue, blurry vision and headaches. Kids seem to become so engrossed in video games that they forget to take breaks.

Prolonged game play without significant breaks can cause eye focusing problems, as well as eye irritation.

Advertisement

Roll over the cup to see what could happen

Learn more at AMDAwareness.org

Genentech

ASRS
AMERICAN SOCIETY OF RETINA SPECIALISTS

Kids and video games

Photo © Jack Hollingsworth / Getty Images

Sponsored Links

Have Blurry Vision?

You may have wet age-related macular degeneration. Learn more.

www.AMDAwareness.org

Xbox 360 Sold for \$39.99

Alert: Xbox 360 are being sold for up to 90% off!

www.Wavee.com

What Does Smoking Cost?

Use Our Smoking Cost Calculator & See What Smoking is Costing You.

www.Itsawaste.org

- Focusing problems:** The eyes focus much differently on a video screen than on a flat surface, such as a piece of notebook paper. When looking at printed material, the brain and eyes understand exactly what distance at which to focus. When looking at a video screen, the eyes are constantly changing focus, making the eyes very tired. Furthermore, when playing video games, the eyes tend to become "locked in" to the screen. This may make it difficult for the eyes to focus easily on other objects, even long after the video game is turned off.
- Irritation:** Kids tend to blink much less frequently while absorbed in a video game. This reduced blinking can significantly affect tearflow, sometimes resulting in dryness and irritation.

Vision Ads

- [Video Games](#)
- [Find PC Video Games](#)
- [Eye Glasses Vision](#)
- [Dry Eyes Eye Health](#)
- [Vision](#)

If your children enjoy playing video games, encourage them to take frequent breaks. Set a timer for 20 minutes, and have them do something else for 5 minutes when the buzzer sounds. Also, make sure your children sit as far away as possible from the video screen. The minimum recommended distance in the case of console games, such as PlayStation, Gamecube, Xbox or Wii, is 6 feet. Setting guidelines for your children will help prevent the negative effects that prolonged video gameplay can have on their eyes.

Source: " [Computer Vision Syndrome](#), " American Optometric Association, 15 Feb 2008.

Suggested Reading

- [Prevent Computer Vision Syndrome in Kids](#)

Related Articles

- [Video Games and Epilepsy - Excerpt from "Epilepsy: Patient and Family Guide...](#)
- [Game Addiction - Is Video Game Addiction Really an Addiction](#)
- [Kids Video Games - Choose Safe Kids Video Games](#)
- [Mental Health, Family Resources - Articles](#)
- [Video Games for Christians - Video Game Options for Christian Parents](#)

Troy Bedinghaus, O.D.
Vision Guide

- [Sign up for my Newsletter](#)
- [My Blog](#)
- [My Forum](#)

234

Figure 3. The Critical Evaluation Webpage for the Snacks and Heart Health Task in the ORCAs

Please see below for LIPITOR Indications
Patient Information Physician Prescribing Information

IMPORTANT SAFETY INFORMATION
LIPITOR (atorvastatin calcium) is not for everyone. It is not for those with liver problems. And it is not for women who are nursing, pregnant or may become pregnant.

HealthCentral
MyHeartCentral.com

Search HealthCentral In Heart Disease Search

Find Manage Connect Free Newsletter Sign up now! My Home Sign In Register Now

Heart Disease Home > SharePosts > Health Professional > Melanie Thomassian > How to Makeover Your Unhealthy Snacks

Font size A A A Email Print Facebook Twitter More RSS Save to My Home This helped!

Saturday, December 18, 2010

How to Makeover Your Unhealthy Snacks

Related: Heart Healthy Diet, More Tags>

It's 3:00pm, your energy levels are dropping, the vending machine seems to be calling your name, and to top it all off your resolve to avoid those unhealthy snacks is weakening with each passing second! What can you do?

Well, the good news is that snacking can be good for you, but only if you choose wisely! In actual fact, one or two well-chosen snacks can help improve your day's total nutritional intake.

Snacking guidelines

The most important thing to be aware of is the type of foods you're snacking on. It's wise to allow no more than 10% of your total day's calorie intake for high fat, or sugar items - that would be around 194 Kcal's for women, and 255 kcal's for men.

Choose foods that don't contain too much fat, sugar or salt, and look out for those that provide you with more calcium, fiber, vitamins and minerals. Take a look at your food labels and try to choose those containing:

- Fat content less than 3 grams per 100 grams
- Sugar content less than 2 grams per 100 grams
- Sodium less than 0.1 grams per 100g

Pack healthy snacks

It's easy enough to cut up a few carrots or celery sticks, add a handful of grape tomatoes, a pot of yogurt, some peanut butter, a hard-boiled egg, or some mixed, unsalted nuts, and add them to your lunchbox the night before.

Let's take a look at some common snacks, and how they could be substituted for healthier options.

Note: calories are given in brackets

#1 Pretzels

2-ounces pretzels

Total calories: 216

Better option:

- 1 small apple sliced (63)
- 1-tablespoon peanut butter for dipping (95)
- 20 raisins, sprinkled on top (31)

Total calories: 189

Please see below for LIPITOR Indications
Patient Information Physician Prescribing Information

IMPORTANT SAFETY INFORMATION
LIPITOR (atorvastatin calcium) is not for everyone. It is not for those with liver problems. And it is not for women who are nursing, pregnant or may become pregnant.

If you take LIPITOR, tell your doctor if you feel any new muscle pain or weakness. This could be a sign of rare but serious muscle side effects. Tell your doctor about all medications you take. This may help avoid serious drug interactions. Your doctor should do blood tests to check your liver function before and during treatment and may adjust your dose.

Common side effects are diarrhea, upset stomach, muscle and joint pain, and changes in some blood tests.

Ask a Question

Get answers from our experts and community members.

Ask a question...

0 / 200 (You may provide more detail after you submit)

Submit >>

View all questions (5081) >

Related Heart Disease Topics

- why is the Atkins diet unhealthy
- snacks on Atkins diet
- how to test fiber content in dry cereal
- time of day snacks to help you sleep
- hcv viral load levels

View All >>

Task in the ORCAs



Never allow children to chew on glow sticks and glow necklaces.

Each Halloween, the state poison center receives more phone calls about glow sticks than any other safety hazard, according to DesLauriers.

Dibutyl phthalate, the chemical that gives the glowing effect, smells unpleasant and is a strong irritant. It can cause corneal abrasion if it comes in contact with the eye and a temporary tingling sensation in the mouth if accidentally swallowed.

Although irritating, it is not considered very toxic, so remain calm in the event of a mishap. "If somebody accidentally gets a taste of it, they're going to be OK," DesLauriers said.

The golden rule for treats: "When in doubt, throw it out."

Deliberate poisonings are not common in Illinois, or the country. "It's not like the poison center is inundated with poisonings on Halloween," DesLauriers said. "It truly isn't."

Just to be on the safe side, the Illinois Poison Center suggests examining all candy before you or your children eat it. Punctured, discolored, unwrapped or partially wrapped candy should be tossed immediately.

Parents of young children should also check for treats that could pose choking

Parents of young children should also check for treats that could pose choking hazards, and avoid accepting homemade goods from strangers, advises the Centers for Disease Control and Prevention.

If people exercise common sense, they should not worry about the deliberate tainting of candy and other Halloween treats, DesLauriers said. It is "so rare that it's certainly not a large risk," she said.

Appendix C. The “About the Author” Pages for the Four Science Tasks in the ORCAs

Figure 1. The “About the Author” Page for the Energy Drinks and Heart Health Task in the ORCAs

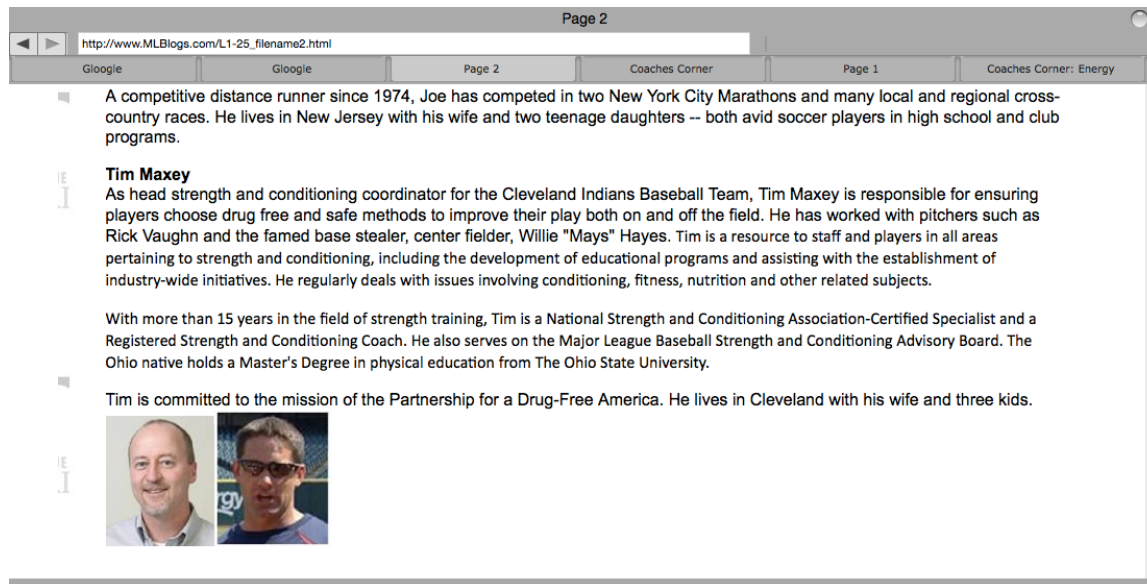


Figure 2. The “About the Author” Page for the Video Games and Eye Health Task in the ORCAs

Dr. Troy L. Bedinghaus

http://www.About.com/L3-23_filename.html

Study: Video games | Video Games Good for | Study: Playing Video | Dr. Troy L. Bedinghaus | Google | Google

Advertisement Sign Up! About.com Cats Newsletter SIGN UP NOW

About.com Vision

Vision Healthy Eyes Eye Problems Vision Correction

Troy Bedinghaus, O.D.
About.com Guide
Email Me | My Blog | My Forum

Free Vision Newsletter!
Enter email address Sign Up
Discuss in my Forum

Dr. Troy L. Bedinghaus is a board-certified optometric physician. He owns and operates Lakewood Family Eye Care, a private eye care facility in Lakewood Ranch, Florida.

Experience:

Dr. Bedinghaus has practiced in many clinical settings including a large, multi-specialty ophthalmology practice, commercial opticals, primary medical rural health clinics and private optometric practices. He is a member of the American Optometric Association and the Florida Optometric Association. He also serves as president of the Manasota Optometric Society.

Education:

Dr. Bedinghaus graduated from Texas A&M University with a bachelor's degree in biology. He then attended the University of Houston College of Optometry, where he earned his doctorate degree in optometry. He completed externships at St. Luke's Cataract and Laser Institute and Manatee/Sarasota Eye Clinic and Laser Center, both in Florida.

From Troy Bedinghaus, O.D.:

With my strong passion for optometry, I will strive to provide the public with valuable information and resources for total eye health. I believe that eye care is an important part of general health, and keeping your eyes healthy is a lifetime commitment.

Sponsored Links

[Avon Medical Group](#)
Quality Healthcare for 50 Years Walk-In Open 7 Days a Week
www.amqcare.com

[AARP Member Discounts](#)
Exclusive AARP member discounts on vision care and eye wear. Look here
www.aarphealthcare.com

[LASIK for Astigmatism](#)
So Cal Experts. Since 1986. LASIK 0 Down 0% Financing Here!
www.LaserEyeCenter.com

Advertisement

HOT DANG
SAVE UP TO 90% ON LOCAL EATS

GROUPON See Today's Deal

www.Groupon.com Ads by Google

Figure 3. The “About the Author” Page for the Snacks and Heart Health Task in the ORCAs

Melanie Thomassian's Profile - HealthCentral

http://www.healthcentral.com/L5-31_filename.html

HealthCentral

Search HealthCentral

My Home

Sign In or Register Now

HealthCentral Home > Profiles > Melanie Thomassian

Saturday, December 18, 2010

Font size A A A

Email


f

t

More

Save to My Home

EXPERT



Melanie Thomassian

Location: United Kingdom

Gender: Female

Bio: Dietitian

Send Message

HEALTH INTERESTS:

Healthy eating, heart health, obesity management, motivating change, and physical activity.

DRUGS I AM TAKING:

Melanie Thomassian has not shared any drug information.

ABOUT ME:

My interest in health care began at a very young age, eventually leading me to the University of Ulster, in Northern Ireland, to study a bachelors degree in Human Nutrition and Dietetics. I am a registered member of the British Dietetic Association, and the Health Professionals Council. I thoroughly enjoy my work as a dietitian, and I am very passionate about all aspects of nutrition. This passion has led me into blog writing, which has given me a wonderful opportunity to pass on my nutritional expertise in a different capacity.

I am extremely interested in heart health, and although I fully support and admire the wonderful heart surgery options available to patients, I am a firm believer that prevention is ultimately the best cure. I hope that through this blog I can discuss topics of interest for those concerned about healthy eating for heart health. It is my desire that individuals will gain a better understanding of the nutritional aspects relating to heart disease, and to promote lifestyle changes that will facilitate eating well as a way of life for all!

I have recently moved back to my homeland in Northern Ireland after spending two years in Australia with my husband. It was wonderful learning the 'Australian way' of things, and I have many fond memories of my time there. My personal interests involve all sorts of cooking and baking, craft, playing the piano, travelling, and keeping fit. I am also involved with weekly children's meetings held at my church, which I find very challenging, but fun!

Melanie Thomassian is the author of Dietrffic.com, an online resource for credible dietary advice, exercise tips, and much more!

PHOTOS:

Melanie Thomassian has not shared any photos.

ROLES:

Health Professional in Heart Disease

Interested in Cholesterol

RECENT ACTIVITY

Notify me when there are new posts

Melanie Thomassian posted 10 Small Steps to Improve Your Eating Habits in 2011

12/15/10

Melanie Thomassian posted 5 Ways to Avoid Holiday Weight Gain

12/13/10

Melanie Thomassian posted Healthy Christmas Menu Ideas

12/11/10

Melanie Thomassian posted 5 Ways to Manage Stress During the Holiday Season

11/23/10

Melanie Thomassian posted Black Friday: No-Fuss Holiday Shopping Options

11/16/10

Ideas That Won't Kill Your Diet!

Melanie Thomassian posted Heart Disease and Diabetes: 5 Ways to Reduce Your Risk

11/08/10

Melanie Thomassian posted Six Benefits Of Exercise (other than weight loss)

11/04/10

Melanie Thomassian posted Keeping Your Cholesterol Under Control: Healthy Ingredient Substitutions

09/13/10

Melanie Thomassian posted Five Ways to Remember to Take Your Heart Medication

08/23/10

VIEW MORE

L7-25_filename2


http://www.Medill.com/L7-25_filename2.html

WEDNESDAY, DECEMBER 15, 2010

MEDILL CHICAGO | MEDILL DC | MEDILL HOME

Julia Dilday

juliadilday@u.northwestern.edu



Julia Dilday is the health reporter for the Medill News Service and a fourth quarter broadcast journalism graduate student. She hails from Long Beach, California and graduated from the University of California with a degree in Health Journalism in 2007.

Dilday covered public health for Medill Reports: Chicago and also reported for the Northwestern News Network. She is an assistant at an eye care clinic and had her first taste of TV news during an internship at CBS5 in San Francisco.

BY THIS AUTHOR

- Breast cancer moves friends and family
- Teens need more talk about 'birds and the bees,' survey finds
- High-tech device hopes to help panicked parents
- More people giving dance a whirl
- Women rally behind breast cancer legislation
- Art at the tip of your fingers
- World Health Day 2009
- More women opting for 'back to basics' births
- Local restaurants whip up allergy-friendly fare
- Chicago seniors flock to free flu shots
- Local kids 'experiment' with science
- More whooping cough cases in Evanston outbreak, city health department says
- Free flu vaccines heading to Chicago neighborhoods
- Daley proposes slashing health department budget 17 percent
- 'Thrifty' homeowners may be playing with fire, officials warn
- Evanston's Science Café offers an inside look into a menu of science buzz
- Parents and scientists pressure retailers to phase out baby products with BPA
- Avoid the tricks that come with the treats: Tips for a healthy, happy Halloween
- E.coli outbreak hits one Illinois county, officials won't say which

Offline Reading Measure

Order 7

PASSAGE I: *Blue Crabs*

PASSAGE II: *Sharebots*

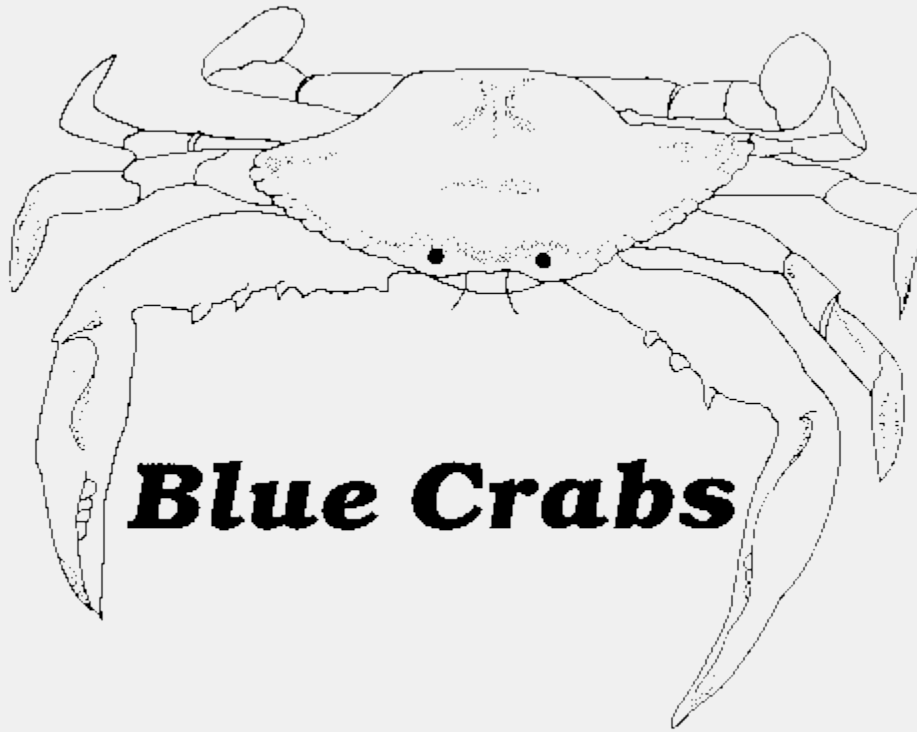
First and last name _____

School _____

Date _____

Directions: Read each passage. Then answer the questions beneath each passage.

PASSAGE I



By George W. Frame

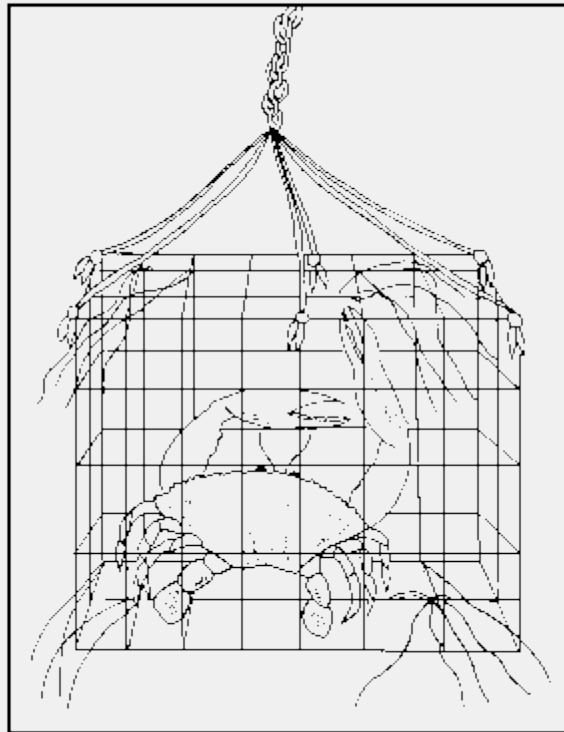
Blue crabs are very strong. Their big claws can make a painful pinch. When cornered, the crabs boldly defend themselves. They wave their outstretched claws and are fast and ready to fight. Keith and I had to be very careful to avoid having our fingers pinched.

Crabs are **arthropods**, a very large group of animals that have an external skeleton and jointed legs. Other kinds of arthropods are insects, spiders, and centipedes. Blue crabs belong to a particular arthropod group called **crustaceans**. Crustaceans are abundant in the ocean, just as insects are on land.

The blue crab's hard shell is a strong armor. But the armor must be cast off from time to time so the crab can grow bigger. Getting rid of its shell is called **molting**.

Each blue crab molts about twenty times during its life. Just before molting, a new soft shell forms under the hard outer shell. Then the outer shell splits apart, and the crab backs out. This leaves the crab with a soft, wrinkled, outer covering. The body increases in size by absorbing water, stretching the soft shell to a much larger size. The crab hides for a few hours until its new shell has hardened. Keith and I sometimes found these soft-shell crabs clinging to pilings and hiding beneath seaweed.

Blue crabs mate when the female undergoes her last molt and still has a soft shell. The male courts her by dancing from side to side while holding his claws



outstretched. He then transfers sperm to the female, where they are stored until egg laying begins several months later. The female blue crab mates only once but receives enough sperm to fertilize all the eggs that she will lay in her lifetime. Usually she lays eggs two or three times during the summer, and then she dies.

When the eggs are fertilized and laid, they become glued to long hairs on the underside of the female's abdomen. The egg mass sometimes looks like an orange-brown sponge and contains up to two million eggs until they hatch — about nine to fourteen days later. Only one of the blue crabs that we caught last summer was carrying eggs, and we returned her to the water so her eggs could hatch. Most females with eggs stay in the deeper, saltier water at the ocean's edge rather than in the marshes.

The young blue crabs, and most other young crustaceans, hatch into larvae that look very different from their parents. The tiny blue crab babies are hardly bigger than a speck of dust. They are transparent and look like they are all head and tail. These larvae swim near the surface of the sea, and grow a new and bigger shell every few days. They soon change in shape so that they can either swim or crawl around on the bottom. Then they molt again and look like tiny adult crabs. After that their appearance does not change, but they continue to molt every twenty or thirty days as they grow.

As blue crabs become older, some move into shallower waters. The males in particular go into creeks and marshes, sometimes all the way to the freshwater streams and rivers. Keith and I caught ninety-two blue crabs in the shallow creek of the tide marsh last summer. Eighty-seven of those crabs were males, and only five were females.

Gulls find and eat many blue crabs. They easily catch crabs that hide in puddles at low tide. Other predators are raccoons, alligators, and people. If caught, the crabs sometimes drop off a leg or claw to escape. Seven of the blue crabs that Keith and I caught were missing a claw.

Crabs are able to replace their lost limbs. If a leg or claw is seriously injured, the crab drops it off. The opening that is left near the body closes to prevent the loss of blood. Soon a new limb begins growing at the break. The next time the crab molts, the tiny limb's covering is cast off, too, and the crab then has a new usable leg or claw. The new limb is smaller than the lost one. But by the time the crab molts two or three more times, the new leg or claw will be normal size.

Many fishermen catch crabs to sell. Most are caught in wire traps or with baited lines during the summer while the crabs are active.

In the winter, the fishermen drag big nets through the mud for the dormant crabs. Commercial fishermen catch a lot of crabs, sometimes more than 50 million pounds in a year. And many other crabs are caught by weekend fishermen who crab for fun and food.

The blue crab has a scientific name, just like all other living things. Its name is *Callinectes sapidus*. In the Latin language *Callinectes* means "beautiful swimmer," and *sapidus* means "delicious." I think that scientists gave the blue crab a very appropriate name.

WO000016

Used by permission of Highlights for Children, Inc., Columbus, OH. © 1988.

"This material is from the National Assessment of Educational Progress which was funded by a federal government grant. This material is in the public domain (excluding any third party copyrighted materials it may contain) and, therefore, our permission is not required to reproduce it. Please reprint any acknowledgement exactly as it appears on the material being reproduced. If no acknowledgement exists, you may just want to acknowledge the source of your materials. You are encouraged to reproduce this material as needed."

For questions 1-3, choose the answer you think is best. Circle the letter of your answer.

1. According to the passage, what do blue crabs have in common with all other arthropods?
 - A. They have a skeleton on the outside of their bodies.
 - B. They hatch out of a shell-like pod.
 - C. They live in the shallow waters of North America.
 - D. They are delicious to eat.

2. The growth of a blue crab larva into a full-grown blue crab is most like the development of
 - A. a human baby into a teen-ager
 - B. an egg into a chicken
 - C. a tadpole into a frog
 - D. a seed into a tree

3. Just after molting, how does a blue crab increase in size?

- A. Its body absorbs water.
- B. It drops off its legs and grows new ones.
- C. Its shell grows the way human bones do.
- D. It eats large quantities of food.

4. Describe the appearance of a female blue crab that is carrying eggs.

5. Why does a blue crab hide after molting?

6. The author of the article helps you to learn about blue crabs by

- A. explaining why they are an endangered species
- B. comparing them to other arthropods
- C. discussing their place in the food chain
- D. providing details about their unique characteristics

PASSAGE II

The Sharebots

by CARL ZIMMER

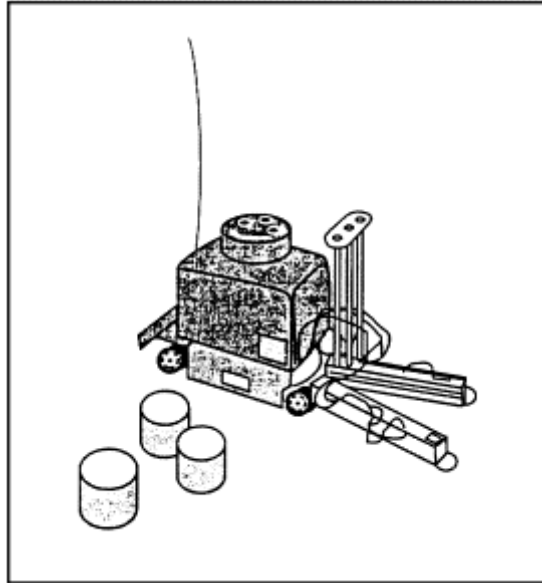
**When robots go to kindergarten in Maja Matarić's lab,
they learn an important lesson about
how to get along in robot society.**

NO MAN IS AN ISLAND, and Maja Matarić thinks no robot should be either. Matarić, a Brandeis University computer scientist, believes robots will do their best work only when they begin to work together. "How do you get a herd of robots to do something without killing each other?" she asks. According to Matarić, you have to put them in societies and let them learn from one another, just as seagulls and baboons and people do. Matarić has already made an impressive start at teaching robots social skills. She has gotten 14 robots to cooperate at once—the biggest gaggle of machines ever to socialize.

The Nerd Herd, as Matarić calls them, are shoe-box-size machines, each of which has four wheels, two tongs to grab things, and a two-way radio. The radio allows them to triangulate their position with respect to two fixed transmitters as they wander around Matarić's lab. It also allows them to broadcast their coordinates and other information to their neighbors. Infrared sensors help the robots find things and avoid obstacles; contact-sensitive strips tell them when they've crashed anyway.

Each robot is programmed with a handful of what Matarić calls behaviors—sets of instructions that enable the robot to accomplish a small goal, like following the robot in front of it. Set one robot on the floor with its wheels turned permanently to the left and program the others to follow, and they will all drive in a circle until their batteries go dead. But Matarić can get more interesting actions out of the herd by programming them to alternate among several behaviors. By telling them to home in on a target, to aggregate when they're too far from one another, to disperse when they're too crowded and to avoid collisions at all times, she's been able to get scattered robots to come together and migrate across her lab like a flock of birds.

More important, the robots can also learn on their own to carry out more complex tasks. One task Matarić set for them was to forage for little metal pucks and bring them home to their nest in a corner of the lab. To give the task a natural flavor, Matarić gave the robots clocks; at "night" they had to go home and rest, and in the "morning" they looked for pucks again. In addition to five basic behaviors they could choose from, she endowed them with a sort of prime directive: to maximize their individual point scores. Each time a robot did something right, such as locating a puck, it was automatically rewarded with points; each time it committed a blooper, such as dropping a puck, it lost points.



Matarić's Nerd Herd, with the pucks they now pursue collectively.

After some random experimentation, the robots soon learned how to forage but not very well, because they tended to interfere with one another in their selfish pursuit of points. "Why should you ever stop and let someone else go?" asks Matarić. "It's always in your interest to go but if everybody feels that way, then nobody gets through and they jam up and fight for space." To make her creatures more efficient, though, Matarić found she didn't have to program them with a God's-eye view of what was good for all robots. She just had to teach each robot to share to let other robots know when it had found a puck, and to listen to other robots in return. "I put in the impetus to pay attention to what other robots are doing, and to try what other robots are trying, sharing the experience," Matarić explains. "If I do some thing that's good and if I say, 'That was really great,' then you may try it."

With this simple social contract, the robots needed only 15 minutes of practice to become altruistic. They would magnanimously announce their discovery of pucks, despite having no way of knowing that this was good for the herd as a whole. At times when two robots lunged for a puck, they would stop and go through an "After you!" "No, after you!" routine, but eventually they figured out the proper way to yield. With social graces, the robot herd brought home the pucks twice as fast as without.

Matarić thinks she'll be able to produce more complex robot societies. "I'm looking at getting specialization in the society so they can say, 'I'll do this, and you do that.' If one of them has a low battery, it may become the messenger that doesn't actually carry things. And I imagine one robot might emerge as a leader because it happens to be the most efficient. But if it stops being efficient, some other robot will take over."

Carl Zimmer © 1995 The Walt Disney Co. Reprinted with permission of Discover Magazine.

1. Circle the answer choice you think is best. The main purpose of the article is to describe how robots can be programmed to

- A. locate metal pucks
- B. work with each other
- C. recharge their own batteries
- D. perform five basic behaviors

2. Do you think "The Sharebots" is a good title for the article? Explain why or why not, using information from the article.

3. Based on how the robots in the article are equipped and the behaviors they are programmed to perform, which of the following jobs could they most likely do in someone's home?

- A. Open cans of food
- B. Open doors and cabinets
- C. Pick up shoes on the floor
- D. Move furniture around a room

4. Maja Matarić describes her group of robots as a "herd." Based on what you know about the behavior of animals in herds, do you think this is a good description? Explain your answer by using examples from the article and what you know about herds.

5. The following sentence appears in the next-to-last paragraph of the article:

"With this simple social contract, the robots needed only 15 minutes of practice to become altruistic."

Based on how the word is used in the article, which of the following best describes what it means to be "altruistic"?

- A. To engage in an experiment
 - B. To provide assistance to others
 - C. To work without taking frequent breaks
 - D. To compete with others for the highest score
6. What change occurred when the robots were taught to share?
- A. They did their jobs more efficiently.
 - B. They could accomplish small goals.
 - C. They performed more specialized tasks.
 - D. They began following each other in a line.
7. Do you think it is a good idea for Matarić to "produce more complex robot societies"? Support your opinion with information from the article.

Appendix D. The Scoring Guide for the Offline Reading Measures

SCORING GUIDE FOR OFFLINE READING ASSESSMENTS

Summary of Score points for Offline Reading Assessments

| Sharebots Gr. 8 | Blue Crabs Gr. 4 |
|--|---|
| Item 1. MC (B) | Item 1. MC (A) |
| Item 2. 3 pt OCR (full, partial, little/no comprehension) | Item 2. MC (C) |
| Item 3. MC (C) | Item 3. MC (A) |
| Item 4. 3 pt OCR (full, partial, little/no comprehension) | Item 4. 2 pt OCR (acceptable/unacceptable) |
| Item 5. MC (B) | Item 5. 2 pt OCR (acceptable/unacceptable) |
| Item 6. MC (A) | Item 6. MC (D) |
| Item 7. 2 pt OCR (acceptable/unacceptable) | N/A |
| N/A | N/A |
| TOTAL: 14 pts 4 MC X 1pt each 2 2pt OCR 1 3pt OCR | TOTAL: 10 pts 4 MC X 1pt each 3 2pt OCR |

Multiple Choice [MC] = 0 (incorrect) or 1 (correct)

2 pt Open Constructed Response [OCR] = 0 (incorrect) or 1 (correct)

3 pt OCR = 0 (No comprehension) 1 (Partial comprehension) 2 (Full comprehension)

SOURCE OF ITEMS: <http://nces.ed.gov/nationsreportcard/itmrlsx/detail.aspx?subject=reading>

SEE NEXT PAGE FOR SPECIFIC DETAILS ABOUT EACH OPEN-CONSTRUCTED RESPONSE ACROSS BOTH STORIES

| Sharebots Gr. 8 | Blue Crabs Gr. 4 |
|--|---|
| Item 2. Sharebots a good title? Why/why not? 3 pt OCR (full, partial, little/no comprehension) | Item 4. Describe appearance of female blue crab carrying eggs 2 pt OCR (acceptable/unacceptable) |
| Item 4. Is herd a good description for the group of robots? 3 pt OCR (full, partial, little/no comprehension) | Item 5. Why does blue crab hide after molting? 2 pt OCR (acceptable/unacceptable) |
| Item 7. Good idea to product more complex robot societies? 2 pt OCR (acceptable/unacceptable) | N/A |

ANSWER KEY AND SCORING GUIDE FOR OFFLINE READING MEASURE

Sharebots (Grade 8)

1. B

2. Scoring Guide – Task: *Do you think "The Sharebots" is a good title for the article? Explain why or why not, using information from the article.*

Evidence of full comprehension:

- These responses provide an opinion about the title and provide appropriate evidence from the article that directly supports the idea of robots sharing with each other, cooperating with each other, or working as a group.

Evidence of partial or surface comprehension

- These responses provide an opinion about the title and support their opinion with a text-based generalization. Or responses at this level may cite evidence from the article that relates to the development of the robots or to the physical activities that can be performed by robots.

Evidence of little or no comprehension

- These responses may provide a yes or no answer, but do not cite appropriate evidence from the article in support of their answer. Their responses display little or no understanding of the text's overall purpose or central idea.

3. C

4. Scoring Guide – Task: *Maja Matarić describes her group of robots as a "herd." Based on what you know about the behavior of animals in herds, do you think this is a good description? Explain your answer by using examples from the article and what you know about herds.*

Evidence of full comprehension

- These responses explain why herd is or is not a good description for a group of robots. They use explicit information from the article and their prior knowledge to make a clear connection between robot behavior and herd-like behavior.

Evidence of partial or surface comprehension

- These responses provide an example of herd-like behavior that is similar to a behavior exhibited by robots, but do not connect it to a specific robot behavior. Or, they may provide an example of robot behavior that is (or is not) similar to herd-like behavior. However, at this level, the connection between robot behavior and herd-like behavior is general or circular (e.g., Animals in herds follow one another just like sharebots do.).

Evidence of little or no comprehension

- These responses may provide a yes or no answer, but they fail to provide any example of robot behaviors from the article, and they do not describe a herd-like behavior that is similar to the behaviors exhibited by the robots. Also, they may merely define "herd."

Examples of herd-like behavior exhibited by the robots:

- following each other
- communicating with each other
- letting each other know that a puck has been found
- working toward a common goal
- competing with each other

5. B

6. A

7. Scoring Guide – Task: *Do you think it is a good idea for Matarić to "produce more complex robot societies"? Support your opinion with information from the article.*

Acceptable:

- These responses provide an opinion about Matarić's plans that reflect at least general

understanding of the kinds of improvements she would like to make. Specific evidence from the article is cited in support of the opinion.

Unacceptable:

- These responses may provide a "yes" or "no" response, but they do not demonstrate understanding of Matarić's plans to continue developing and improving what the robots can do. No evidence, or inappropriate evidence may be cited from the article.

Blue Crabs (Grade 4)

1. A

2. C

3. A

4. Scoring Guide – Task: *Describe the appearance of a female blue crab that is carrying eggs.*

Acceptable:

- Responses mention that she carries an orange-brown sponge or she has eggs on her abdomen or underside. For example: "Long hairs with glue holding 2 million eggs."

Unacceptable

- Responses contain inappropriate or incorrect information. For Example: "She has a sack of eggs in her claws."

5. Scoring Guide – Task: *Why does a blue crab hide after molting?*

Acceptable:

- Responses indicate that the blue crab is helpless without its shell and cannot defend itself, so it hides. Also accept responses that only mention soft shell, or the need to protect themselves.

Unacceptable

- Responses give reasons that are contradicted or not supported by information in the text, such as, "Blue crabs hibernate after their soft shells fall off." Or, "Blue crabs feel funny, so they hide."

6. D

NAEP Questions Tool:

<http://nces.ed.gov/nationsreportcard/itmrlsx/search.aspx?subject=reading>