

The New Literacies of Online Research and Comprehension: Rethinking the Reading Achievement Gap

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ABSTRACT

Is there an achievement gap for online reading ability based on income inequality that is separate from the achievement gap in traditional, offline reading? This possibility was examined between students in two pseudonymous school districts: West Town (economically advantaged) and East Town (economically challenged; $N = 256$). Performance-based assessments were used within a simulation of the Internet developed as part of a larger project. Seventh graders completed two online research and comprehension assessments, which evaluated four skill areas (locate, evaluate, synthesize, and communicate) and two knowledge domains in science. Students also completed an assessment of prior domain knowledge and a short Internet use questionnaire. Standardized state reading and writing test scores served as measures of offline literacy skills. Results indicated that there was a significant achievement gap favoring West Town students in offline reading scores, offline writing scores, and online research and comprehension scores. A significant gap persisted for online research and comprehension after we conditioned on pretest differences in offline reading, offline writing, and prior knowledge scores. The results of the questionnaire indicated that West Town students had greater access to the Internet at home and were required to use the Internet more in school. These results suggest that a separate and independent achievement gap existed for online reading, based on income inequality. Current estimates of this gap, which rely solely on measures of offline reading, may underrepresent the true nature of the U.S. reading achievement gap in an online age. Policy implications are explored.

Education and opportunity have long been linked to public policy in the United States (*Brown v. Board of Educ.*, 1954; Mann, 1855; National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA Center & CCSSO], 2010). Intertwined with this history, the ability to read at high levels has always been considered important, permitting an essential pathway to advancement for everyone, especially the least privileged (cf. Chall, 1967; Huey, 1908). Despite attempts at policy remedies, a substantial gap based on income inequality continues to exist in students' reading achievement levels (National Center for Educational Statistics [NCES], 2011b, 2013), and evidence indicates that it is growing, over time (Reardon, 2013). In a society that professes egalitarian ideals and equal opportunity through education, a reading achievement gap based on income inequality should be a concern of every citizen.

Reading has been shifting from page to screen (Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012; Hartman, Morsink, & Zheng, 2010), but analyses of reading achievement gaps have only evaluated

differences in offline reading (cf. NCES, 2011b, 2013; Reardon, 2013; Reardon & Galindo, 2009). Is there an achievement gap for online reading ability based on income inequality that is independent of the achievement gap in traditional, offline reading? If so, the actual reading achievement gap would be greater than we recognize today. The current study explores this issue, one that is important to public policy, assessment, and instruction during new, online times.

Perspectives

New Literacies: A Dual-Level Theory

Ever since the term *new literacies* was used by Gallego and Hollingsworth (1992), it has represented many different perspectives (cf. Baker, 2010). Typically, this term suggests that literacy is rapidly changing and transforming as new information and communication technologies emerge and as additional discourses, social practices, and skills are required to make use of these technologies (e.g., Baker, 2010; Gee, 2007; Lankshear & Knobel, 2006). Moreover, with the Internet, literacy is not just new today; it is new every day, as additional technologies for literacy regularly and rapidly appear online (Leu, 2000).

The rapidly evolving nature of literacy presents an important challenge for theory development (Coiro, Knobel, Lankshear, & Leu, 2008; see also Tierney, 2009). How can adequate theory be developed when the object that we seek to study is itself ephemeral, continuously being redefined by a changing context? Recently, a dual-level theory of New Literacies has been proposed to respond to this problem (Leu, Kinzer, Coiro, Castek, & Henry, 2013). It conceptualizes new literacies on two levels: uppercase (New Literacies) and lowercase (new literacies). We used both levels of New Literacies theory to frame this study.

Lowercase theories explore a specific area of new literacies and/or a new technology, such as the social communicative transactions occurring with text messaging (e.g., Lewis & Fabos, 2005). Lowercase perspectives also include those that explore a focused disciplinary base, such as the semiotics of multimodality in online media (e.g., Kress, 2003); a distinctive conceptual approach, such as new literacy studies (Street, 1995, 2003); or online literacies within a specific developmental level (e.g., Alvermann, Hutchins, & McDevitt, 2012; Marsh, 2011). These lowercase theories are better able to keep up with the rapidly changing nature of literacy in a deictic world because they are closer to the specific types of changes that are taking place. Lowercase theories also permit our field to maximize the lenses we use and the technologies and contexts we study.

New Literacies, as the broader concept, benefits from work taking place in the multiple, lowercase dimensions of new literacies, where rapid changes are more easily studied and identified. When common findings across multiple, lowercase perspectives are integrated into a broader New Literacies theory, we have a set of guiding principles that are more stable over time. The greater stability of New Literacies theory may provide theoretical direction to inform research into the more rapidly changing contexts at lowercase levels.

One of several principles of uppercase New Literacies (Leu, Kinzer, et al., 2013) is that the Internet makes new social practices possible with technologies such as instant messaging, social networks, blogs, wikis, and e-mail, among others (cf. Greenhow, Robelia, & Hughes, 2009; Lewis & Fabos, 2005). Thus, this study situated online research and comprehension assessments (ORCAs) within a social network that included some of the new social practices associated with these technologies.

The New Literacies of Online Research and Comprehension

The new literacies of online research and comprehension (Kingsley & Tancock, 2014; Leu, Kinzer, et al., 2013) is one of many lowercase theories of new literacies. Initially, the term *online reading comprehension* was used (cf. Coiro, 2011; Coiro & Dobler, 2007; Henry, 2007; Leu, Kinzer, Coiro, & Cammack, 2004). Unfortunately, the term has led to some confusion because it contrasted offline reading comprehension with online reading comprehension within a new literacies context. This implied that the two were separate and completely different, whereas evidence shows that there is a complex mixture of both offline and new online elements that take place during online reading (Coiro, 2011; Coiro & Dobler, 2007).

There is also a question as to whether anything is really “new.” Perhaps this is because individuals first encountering the construct assumed a limited online reading activity. There are many situations in which we might read online, such as when we read an e-mail message, an online newspaper, or a single webpage. When these occur as isolated reading acts, they do not appear to differ in substantial ways from offline reading comprehension except for the online context; there is likely to be little that is substantially new (Leu, Kiili, & Forzani, in press). Usually, however, online reading does not take place within isolated contexts (Leu, Kinzer, et al., 2013). Instead, online reading typically occurs within a richly integrated and complex process of inquiry and problem solving as we seek answers to questions large and small and use the Internet to comprehend and learn, almost always from informational

text (Kuiper & Volman, 2008), often in a highly social nature (Lankshear & Knobel, 2006), and frequently with multiple media forms (Kist, 2005).

Offline reading can take many forms, whereas online reading is typically much more focused on reading to solve a problem or answer a question—that is, to learn something one seeks to know more about. It is not that one cannot manifest elements of online reading during offline reading, as research and inquiry can take place offline as well as online, although with somewhat different tools. It appears, however, that online reading is especially focused around inquiry and learning (Kuiper & Volman, 2008; Lawless & Schrader, 2008). Given the increased importance of online information in our lives (Organisation for Economic Co-operation and Development [OECD], 2010), it is possible that online reading (i.e., inquiry reading) becomes especially important for learning and education as students advance through our educational systems (NGA Center & CCSSO, 2010).

As a result of additional knowledge about the nature of online reading, the more precisely descriptive term *new literacies of online research and comprehension* has replaced *online reading comprehension* (Kingsley & Tancock, 2014; Leu, Kinzer, et al., 2013). The new term is more accurate and makes the somewhat distinctive nature of online reading easier to understand because online research requires skill with additional technologies (e.g., search engines, text messaging, note-taking tools) and also requires additional social practices (e.g., using a search engine to locate information about the creator of a website to help determine the reliability of the information).

The new literacies of online research and comprehension seek to describe what happens when we read online to learn. Leu, Kinzer, et al. (2013) suggest that at least five processing practices occur during online research and comprehension: reading to define important questions (Taboada & Guthrie, 2006), reading to locate online information (Kuiper & Volman, 2008; Lawless & Schrader, 2008), reading to critically evaluate online information (Sanchez, Wiley, & Goldman, 2006), reading to synthesize online information (Goldman, Wiley, & Graesser, 2005; Jenkins, 2006), and reading and writing to communicate online information (Greenhow et al., 2009).

Reading to Define Important Questions

We read on the Internet to solve problems and answer questions. How a problem is framed or how a question is understood is a central aspect of online research and comprehension. Work by Taboada and Guthrie (2006) within traditional texts suggests that reading initiated by a question differs in important ways from reading that is not.

Reading to Locate Online Information

Successful online research and comprehension requires the ability to generate effective keyword search strategies (Bilal, 2000; Eagleton, Guinee, & Langlais, 2003; Kuiper & Volman, 2008), to read and infer which link may be most useful within a set of search engine results (Henry, 2006), and to scan efficiently for relevant information on websites (Rouet, 2006; Rouet, Ros, Goumi, Macedo-Rouet, & Dinet, 2011). If one cannot locate information, one will be unable to solve a given problem (Foss, 2014; Guinee, Eagleton, & Hall, 2003). Consequently, each of our ORCAs included items designed to capture students' ability to query search engines and interpret the relevancy of search results in relation to their particular reading needs.

Reading to Critically Evaluate Online Information

Another component of successful online research and comprehension is the ability to critically evaluate information encountered on the Internet (Bråten, Strømsø, & Britt, 2009; Leu, Kinzer, et al., 2013). Critical evaluation online presents challenges quite different from traditional offline print and media sources because the content of online information is even more diverse (Kuiper & Volman, 2008) and commercially biased (Fabos, 2008). While many different aspects of critical evaluation exist, we focused particular attention in this study on the critical evaluation of source information (Bråten et al., 2009).

Reading to Synthesize Online Information

Successful online research and comprehension also requires the ability to read and synthesize information from multiple online sources (Jenkins, 2006). Synthesis, or the integration of separate and unique ideas, is thought to be the most challenging of offline comprehension strategies (Keene & Zimmermann, 1997) because it requires the reader to bring together an awareness of the reading processes and an underlying understanding of the text (Dole, Duffy, Roehler, & Pearson, 1991). The Internet introduces additional challenges for coordinating and synthesizing vast amounts of information presented in multiple media formats from a nearly unlimited and disparate set of sources (Leu, Kiili, & Forzani, in press). Thus, our assessments sought to capture students' ability to synthesize multiple texts for a particular reading need.

Reading and Writing to Communicate Online Information

A final component of successful online research and comprehension is the ability to read and communicate

via the Internet while interacting with others to seek more information or to share what you have learned (Greenhow et al., 2009). The communication processes involved in using a range of online tools to ask and answer questions on the Internet appear to be inextricably linked to aspects of online research and comprehension (Leu, Slomp, Zawilinski, & Corrigan, in press). Online communication skills were included in the assessments of this study.

These areas are thought to comprise most of the skills, strategies, dispositions, and social practices that are distinctive to online research and comprehension in a complex layering of both offline and online reading that we are still seeking to fully understand. We used this lowercase theory of online research and comprehension to inform the operational definition of online reading in the current study. Specifically, we evaluated students' ability to locate, evaluate, synthesize, and communicate information during an online research task.

Previous Research

Achievement Gaps in the United States

Offline Reading

On both the 2011 and the 2013 National Assessment of Educational Progress (NAEP) for reading, there was a difference of two thirds of a standard deviation in scaled reading scores between eighth-grade students eligible for the National School Lunch Program and those who were not (NCES, 2011b, 2013). The difference favored economically advantaged students. This is roughly the difference between scores at the 25th percentile and the 50th percentile (see NCES, 2011b, 2013) or two to three years of schooling in the middle school and high school years (see Hill, Bloom, Black, & Lipsey, 2008).

Even more troubling, the offline reading achievement gap based on income inequality is increasing (Bailey & Dynarski, 2011; Reardon, 2011, 2013). Between 1976 and 2001, the achievement gap in reading increased by nearly 40% for children raised in families with incomes at the 10th percentile, as compared with children raised in families with incomes at the 90th percentile (Reardon, 2011). Using a 10th–90th percentile family income metric, the achievement gap is nearly 1.25 standard deviation units, or roughly equivalent to three to six years of schooling in the middle school and high school years (Reardon, 2011).

To put this gap in comparative terms, the gap between rich and poor is now approximately double the black–white achievement gap in reading, which has

been declining during the same period (Reardon, 2011). Particularly troubling is that income inequality in the United States is also increasing (Congressional Budget Office, 2007), suggesting that the offline reading achievement gap may get even larger over time.

Reading is an important gateway to learning and success in school (Anderson, Hiebert, Scott, & Wilkinson, 1985). Children who fall behind in reading achievement are unlikely to catch up later (Annie E. Casey Foundation, 2010; Snow, Burns, & Griffin, 1998). The result of falling behind in reading is a loss of opportunity, both for individuals and for our larger society (NCES, 2013). The persistent achievement gap in reading, based on income inequality, may contribute to stagnating economic mobility in the United States; economic mobility is now less than in Europe and other developed nations (Chetty, Hendren, Kline, & Saez, 2014).

Science

In a global economy, the preparation of students in science and related fields is essential (National Research Council, 2007; President's Council of Advisors on Science and Technology, 2010). Both human and economic advances may be jeopardized by the large and increasing gap in science achievement among students who attend school in the United States (Members of the 2005 "Rising Above the Gathering Storm" Committee, 2011).

On the 2009 NAEP for science, there was a difference of nearly one standard deviation between eighth-grade students eligible for the National School Lunch Program and those who were not (NCES, 2009). This represents a difference between scoring at the 20th percentile and the 50th percentile (NCES, 2011a) or two to three years of schooling in the middle school and high school years (see Hill et al., 2008). The current study was conducted within the discipline of science because it is increasingly important (National Research Council, 2011) and because achievement gaps based on income inequality were also found in this subject area.

Writing Ability

Writing to communicate information is one aspect of online research and comprehension. We write to acquire new information, to ask questions about what we find, and to share what we have learned online with others (Britt & Gabrys, 2001; Leu, Slomp, et al., in press). There was a difference of 0.77 standard deviation units in offline writing performance between eighth graders in the United States who were eligible for free or reduced-price lunch and those who were not (NCES, 2011c) or two to three years of schooling in the middle school and high school years (see Hill et al., 2008).

In this study, we wanted to distinguish between offline reading comprehension and online research and comprehension, which includes online communication skills with writing. Thus, we conditioned on offline writing in our statistical models. This extends previous work that studied differences between online and offline reading comprehension (Coiro, 2011) but did not consider offline writing ability as a potentially confounding factor.

Online Research and Comprehension

The ability to comprehend what is read during online research and learning is important to knowledge-based societies (Goldman et al., 2012; PIAAC Expert Group on Problem Solving in Technology-Rich Environments, 2009). Recent studies have shown that online research and comprehension is not isomorphic with offline reading comprehension (Afflerbach & Cho, 2010; Coiro & Dobler, 2007; Leu et al., 2007). There appears to be a complex relationship between the offline and online skills that are required when one moves from traditional texts to conducting research and comprehending information in an online environment (Afflerbach & Cho, 2010; Coiro & Dobler, 2007; Hartman et al., 2010). 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). Many strategies centered around a reader’s ability to apply methods to reduce their levels of uncertainty while navigating and negotiating appropriate reading paths in a shifting problem space (see also Cho, 2010; Zhang & Duke, 2008).

Coiro and Dobler (2007) found that online research and comprehension involved the use of offline reading comprehension skills, but that it was more complex and included a number of additional skills. This supports an earlier finding that there was a smaller than expected correlation between scores on a state reading comprehension assessment and an ORCA (Leu, Castek, & Hartman, 2006). Another study used a regression model to predict online reading performance (Coiro, 2011). It conditioned on offline reading and prior knowledge scores and found that an additional 16% of variance was accounted for by knowing students’ previous online research and comprehension ability. This also indicates that additional skills, beyond those required for offline reading, are required for online research and comprehension.

Finally, case studies and videos of online reading show that students who score low on state reading assessments sometimes perform at unexpectedly high levels on tasks of online research and comprehension (Castek, Zawilinski, McVerry, O’Byrne, & Leu, 2011;

Leu et al., 2007). Although we do not fully understand the source of the differences between offline reading comprehension and online research and comprehension, there is considerable evidence to suggest that the two are not identical (Afflerbach & Cho, 2010; Castek et al., 2011; Coiro, 2011; Coiro & Dobler, 2007; Hartman et al., 2010; Leu et al., 2006, 2007; Zhang & Duke, 2008).

Why is a difference between offline reading and online research and comprehension important? If the two were isomorphic, an identical achievement gap based on income inequality would be predicted. The fact that the two appear somewhat different suggests that a separate and independent achievement gap could exist for online research and comprehension. Preliminary work has suggested that a gap in online research and comprehension ability exists based on income inequality (Henry, 2007). However, that study did not determine whether the gap was independent of offline reading ability. If a separate and independent gap exists, it would suggest that the achievement gap reported for offline reading underrepresents the magnitude of the challenge.

Internet Access at Home

According to the National Telecommunications and Information Administration (2011), 32% of all households with incomes of less than \$15,000 had a minimum level of broadband access (200 kbps) compared with 90% of families with incomes over \$150,000. A home access gap has also been reported by the Pew Research Center (2012), which showed that 38% of lower income households (<\$30,000 in household income per year) do not use the Internet, compared with only 3% of upper income households (>\$75,000 in household income per year) in the United States.

The lack of Internet access at home may be one important source of an achievement gap in online research and comprehension (Henry, 2007). When compounded with lower achievement levels in offline reading between these same two groups of students, as demonstrated by NAEP (NCES, 2013) data, students who come from lower income families may be doubly disadvantaged (Leu, Kinzer, et al., 2013). In this study, we asked students from both districts to report on their Internet access at home and at school.

Prior Knowledge

The knowledge that readers bring to a text plays an important role in their comprehension of offline material (e.g., Kintsch, 1998; McNamara & Kintsch, 1996; Voss & Silfies, 1996) and is likely to play a similar role during online research and comprehension. Information stated in a text is often insufficient for the construction of a

coherent mental representation of the situation, requiring the contribution of a reader's prior knowledge (Kintsch, 1998; McNamara & Kintsch, 1996; Voss & Silfies, 1996). This is particularly apparent with expository/informational text materials (Afflerbach, 2007; Chi, Feltovich, & Glaser, 1981). In this study, we wanted to be able to rule out pretest differences in prior knowledge as the source of differences between students in the two districts. Thus, our statistical models conditioned on prior domain knowledge of the science topics relevant to our ORCA.

ORCAs

Previously, ORCAs have taken place within the dynamic reality of the Internet (Castek, 2008; Coiro, 2011; Henry, 2007). However, each suffered from content stability issues because it was possible for target websites to change during data collection. As a result, an assessment used at one time was not always comparable to the same assessment used at another time.

Several lines of work recently have emerged to solve the content stability issue in the assessment of online reading, problem solving, and inquiry: the PISA Digital Reading Assessment (OECD, 2011); PIAAC's problem solving in technology-rich environments (PIACC Expert Group on Problem Solving in Technology-Rich Environments, 2009); Global, Integrated, Scenario-Based Assessments (Sabatini, O'Reilly, Halderman & Bruce, 2014); ePIRLS (Mullis & Martin, 2013); and ORCAs (Leu, Kulikowich, Sedransk, & Coiro, 2009–2014). This is an early study from the latter initiative, the ORCA Project (Leu et al., 2009–2014), which is a five-year research project designed to develop three formats of performance-based ORCAs and to evaluate their psychometrics. The assessments focused on knowledge domains associated with health and human body systems, a common curricular area in science for seventh graders in the United States (Achieve, 2014). The present study used an early assessment design and two ORCAs in just one format, a simulation. Following the current study, we also modified the assessments slightly to make them easier to administer and score and to reduce the administration time. Subsequent work used much larger and different populations during each of the following two years, as well as three different formats (simulation, multiple-choice, and the actual Internet) and many more ORCAs.

We used these first two ORCAs, in the simulation format, to evaluate the research questions for this study:

1. Is there an achievement gap in offline reading comprehension between seventh-grade students in an economically advantaged and an economically challenged school district?

2. Is there an achievement gap in online research and comprehension between seventh-grade students in an economically advantaged and an economically challenged school district?
3. When we condition on pretest differences in offline reading ability, prior domain knowledge, and offline writing ability, is there a separate and independent achievement gap in students' ability to conduct online research and comprehend information in science that is based on income inequality?

Method

Participants

Participants came from seventh-grade cohorts in two schools in two different districts purposively selected to represent different social and economic strata. The districts were in a Northeastern state, Connecticut, which was ranked fourth in the United States in median family income (Noss, 2012). In this state, a District Reference Group (DRG) system was used to classify districts by socioeconomic level (see Connecticut State Department of Education, 2006). These DRGs included eight levels of economic status, ranging from A (high) to I (low). The DRG system was used to select a purposive convenience sample of two districts, one from within a higher level DRG and one from within a lower level DRG. One district, referred to as West Town (pseudonym), was chosen from the second-highest level (B) and the other, referred to as East Town (pseudonym), from the second-lowest level (H).

Several economic and technological indicators for each district are presented in Table 1. The median family income for West Town was twice that of East Town, and the percentage of students who were eligible for free or reduced-price lunch was nearly 17 times greater for East Town compared with West Town. Both schools had comparable Wi-Fi capabilities and similar profiles of Internet-connected computers with high or moderate power available to students. The middle school at East Town had a slightly better ratio of students per instructional computer connected to the Internet (3.3) compared with the middle school at West Town (3.7).

We deliberately selected these two districts because each had only a single middle school. This ensured that participating students closely represented the larger community in each district. We requested participant permission for all seventh-grade students in each school. Ninety percent of all seventh graders in both districts returned signed parental permission forms: 174 students from West Town and 162 students from East Town. Grade 7 was selected because this is often the level when learning disciplinary information becomes especially important to academic success (Shanahan & Shanahan, 2012).

TABLE 1
Economic and Technological Indicators for West Town and East Town (pseudonyms) School Districts in Connecticut

Economic or technological indicator	West Town	East Town
Median family income	\$119,228	\$58,981
Percentage of families below the poverty line	2%	12%
Percentage of students eligible for free or reduced-price lunch	4%	67%
Number of students per instructional computer at the middle school	3.7	3.3
Percentage of computers with Internet access at the middle school	100	100
Percentage of computers with high or moderate power at the middle school	100	100

On the first day of the study in West Town, we experienced technological issues during the first two testing sessions. As a result, 36 students in West Town only completed the assessment “How Do Energy Drinks Affect Heart Health?” (“Energy Drinks”). Another 30 students only completed the assessment “Can Chihuahua Dogs Cure Asthma?” (“Asthma”). In East Town, 10 students were only able to complete the assessment “Energy Drinks” (and not “Asthma”) and four were only able to complete the assessment “Asthma” (and not “Energy Drinks”). Students who only completed one of the two assessments were dropped from the primary analyses used for this study. This resulted in a total loss of 66 students from West Town and 14 students from East Town. They were, however, included in a set of secondary analyses (and reported in the Results section) that we used to evaluate data loss.

Table 2 presents the basic demographic data on participating students. The final sample for the primary

analyses in this study consisted of 256 seventh graders in two districts who completed both assessments: “Energy Drinks” and “Asthma.”

Offline Reading Comprehension

The state reading assessment, part of the Connecticut Mastery Test (CMT) and administered two months prior to this study, measured traditional, offline reading comprehension (Connecticut State Board of Education, 2010). This assessment contained no items that measured online research and comprehension skills. We obtained scores for 238 of the 256 students used in this study: 103 out of 108 students from West Town and 135 out of 148 students from East Town.

The CMT for reading provided a combined scaled score of the ability to understand nonfiction English prose as well as narrative passages on a variety of topics (Connecticut State Board of Education, 2010). The reliability estimate for this instrument is .95, using

TABLE 2
Information on Participating Seventh-Grade Students in West Town and East Town (pseudonyms) School Districts in Connecticut

Student information	West Town	East Town	Total
Students who completed both research tasks	108	148 ^a	256
Boys	50	80	130
Girls	58	67	125
Percentage of students at each middle school who were not fluent in English and received special services in this area	0.8%	7.0%	
Percentage of students at each middle school who were identified as receiving special education services	8.4%	12.9%	
Students who only completed the “How Do Energy Drinks Affect Heart Health?” research task and not the “Can Chihuahua Dogs Cure Asthma?” research task because of technological issues ^b	36	10	46
Students who only completed the “Asthma” research task and not the “Energy Drinks” research task because of technological issues ^b	30	4	34

^aGender information on one student was missing from East Town.

^bThese students were included in secondary analyses (see the Results section of the article) to evaluate the loss of these data.

Cronbach's α (Hendrawan & Wibowo, 2011). Studies with the teachers of the state and other experts have been conducted to establish the content validity for the reading assessment (see Hendrawan & Wibowo, 2011, for a full report on validity). Concurrent validity was established with high correlations between CMT scores and the Metropolitan Achievement Test for reading (Hendrawan & Wibowo, 2011).

Mean scaled scores on the CMT for reading for participating students were 282.60 for West Town and 215.10 for East Town. The mean scaled score in reading for participating West Town students fell within the highest of five score bands (advanced), whereas the mean scaled score in reading for participating East Town students fell within the middle of five score bands (proficient; see Connecticut State Board of Education, 2010).

Prior Domain Knowledge of the Topic

Prior domain knowledge of the research topic was evaluated using verbal protocols and idea unit analysis (the number of propositions provided by a student), an approach with demonstrated reliability (Wolfe & Goldman, 2005). Prior knowledge scores for both topics were obtained from all 256 students used in this study. We gathered data on prior domain knowledge online before students began each research task. They were prompted to enter all that they knew about the topic in a window on their laptop. After every 15 seconds, they were prompted by the system to enter additional information that they knew about the topic. When 15 seconds went by without an entry, a button became available that said, "I don't know anything else." Prior knowledge entry concluded when students selected this button and began the research task.

Validity was established through extensive cognitive labs over two years with approximately 300 students. We carefully reviewed think-aloud responses and discussed them with students to determine whether this approach to prior knowledge provided a reasonable representation of their prior knowledge. We made adjustments in the protocol based on these experiences.

Idea unit analysis was conducted on all entries. Each proposition received 1 point. Two scorers were trained to 90% accuracy with a sample set, and disagreements were resolved through discussion. The scorers then scored all prior knowledge entries.

Offline Writing Ability

Scaled scores from the CMT for writing, administered two months prior to the study, measured offline writing ability. No items specifically measured online writing ability. CMT writing scores were obtained for 249 of the 256 students used in this study: all 108 of the students from West Town and 141 out of 148 students from East Town. The offline writing assessment included two tests: the

Direct Assessment of Writing, and Editing and Revising (Connecticut State Board of Education, 2010). The reliability estimate for this instrument is .89, using Cronbach's α (Hendrawan & Wibowo, 2011). For scoring, there was a decision consistency reliability of .96 and a decision accuracy reliability of .94 (Hendrawan & Wibowo, 2011).

Studies with the teachers of the state and other experts have been successfully conducted to establish content validity (see Hendrawan & Wibowo, 2011, for a full report on validity). Concurrent validity was established with high correlations between CMT writing scores and the scores of other English language arts assessments used in the state (Hendrawan & Wibowo, 2011).

ORCAs

Performance-based assessments were used to measure online research and comprehension ability. Two online simulations of the Internet, with structurally similar scenarios, presented problems in science within a social network for students to solve using online information and various Internet tools. Problems came from the domains of health and human body systems.

In the first scenario ("Energy Drinks"), a programmed avatar student asked participating students to check their e-mail inbox to locate a message from the principal of a middle school. The principal's e-mail asked students to conduct research on how energy drinks affect adolescents' heart health using the Internet and then to send an e-mail with a short report of the findings (see Figure 1 and Leu, Forzani, et al., 2013).

The second scenario, "Asthma," presented students with a wiki used in a science classroom. The avatar asked students to read the information that had been posted on the classroom wiki page about asthma. Then, the avatar directed students to conduct research online and determine whether Chihuahuas can cure asthma, a popular urban legend in some cultures. Finally, after completing the research, the avatar asked students to use their findings to revise the class's wiki about asthma.

An extensive collection of webpages was imported into a closed space on the Internet for each ORCA. An internal search engine ("Gloogle") was created to locate webpages that had been imported. Each ORCA also included closed e-mail and wiki systems, as well as a closed social network system with texting/chatting capability. Fictitious teachers, principals, and students, represented with additional avatars, prompted each student throughout the research process within the social network interface via text messages (an overview video of the simulation format is available at bit.do/ORCA-simulation). Each assessment followed a parallel scenario structure, in which students were asked to locate four different websites, synthesize information across them, and critically evaluate one of the sites. Students were then asked to write a short report in

FIGURE 1
An Example of the Social Network Context for the Assessment “How Do Energy Drinks Affect Heart Health?,” an e-Mail Communication Task



Note. These images contain the sequential messages from the avatar, guiding each student through the research task. Here, the avatar directs the student to the initial e-mail from the principal, defining the nature of the research request from the president of the school board. From “The New Literacies of Online Research and Comprehension: Assessing and Preparing Students for the 21st Century With Common Core State Standards,” by D.J. Leu et al., in S.B. Neuman and L.B. Gambrell (Eds.), 2013, *Quality Reading Instruction in the Age of Common Core Standards* (p. 228), Newark, DE: International Reading Association. Copyright 2013 by the International Reading Association. Reprinted with permission.

either an e-mail message or on the class wiki, depending on the scenario. (The scenarios for “Energy Drinks” and “Asthma” are available at pubs.newliteracies.uconn.edu/energy-drinks-lesc and pubs.newliteracies.uconn.edu/asthma-lesc-script, respectively.)

Scoring

Each scenario formed a testlet (Wainer, Bradlow, & Wang, 2007), called a LESC (locate, evaluate, synthesize, and communicate), and students were evaluated with respect to each of these four skill areas as well as a total score. Each LESC contained 16 total score points (see Table 3), with four points assigned to each skill area. Each of the 16 score points evaluated an online research and comprehension skill that had been identified from discussions with experts, based on previous research.

Each of the four skill areas (LESC) included three process skills and one product skill. Four experts in online research and comprehension scaled the three process skills by the likely order of difficulty, so each skill was considered more difficult than the one before. Each of the four product skills was considered to be a culminating task for its given area and, therefore, was intended to be the most difficult of the four score points in that area.

The LESC components did not appear in a strictly linear sequence (e.g., the assessment did not begin with locate tasks, followed by evaluate tasks, etc.), nor did the four skills that were evaluated within a component dimension. Instead, a more logical and natural sequence of events developed within the scenario. The one exception was the evaluation sequence, which asked students to evaluate one of the webpages in four areas with sequential

TABLE 3
The Skill Areas for Online Research and Comprehension Evaluated in Each Locate, Evaluate, Synthesize, and Communicate Scenario

Score point number	Reading to locate online information	Reading to critically evaluate online information	Reading to synthesize online information	Reading and writing to communicate online information
1	On the first search task, did the student use appropriate keywords, entering both topic and claim as search terms?	Was the student able to correctly identify the author/creator of the focal website?	In the first summary of what was learned, did the student include two details in his or her own words from the first website?	Was the student able to use the communication tool (e-mail or wiki) to send or post a message with an appropriate heading or subject?
2	For the first search task, did the student read, infer, and select a correct site from search results on the first click?	Was the student able to provide an accurate detail about the author's level of expertise?	In the second summary of what was learned, did the student show evidence of intertextual information use, integrating information across the first two websites?	Was the student able to communicate in a way that demonstrated awareness of audience?
3	For the second search task, did the student read, infer, and select a correct site from the search results on the first click?	Was the student able to provide accurate information about the effectiveness of the author's use of evidence for arguments?	In the third summary of what was learned, did the student show evidence of intertextual information use, integrating information across the first two websites?	Did the student use any visual elements to make meaning clearer?
4	Did the student correctly identify both website addresses from the two search tasks in a text message?	Was the student able to provide a reasonable evaluation and logical explanation of the focal website's reliability?	In the argument, did the student include a claim with evidence using two relevant details?	Did the student craft an explicit, unambiguous response to the question?

requests from the student avatar (see Table 3 for the four skills that were evaluated).

A data capture system was developed to record and track students' online reading decisions for subsequent scoring. Video screen captures were also used for a richer interpretation of student performance, as well as a backup for the data capture system.

Four graduate students served as scorers, working in pairs for each topic. They evaluated performance following a common rubric for each of the 16 score points. Each score point was evaluated using a binary (i.e., 0 or 1) scoring system. Scorers were initially trained on a common set of 10 scenarios. Then, they were each tested for accuracy on another set of 10 scenarios and were required to reach 90% inter-rater agreement for each of the 16 score points before being allowed to score the actual student assessments. The scoring pairs compared their scoring at several points throughout to reevaluate their reliability of scoring decisions. Each time this reliability check was conducted, inter-rater reliability met or exceeded 90% for each score point within each scenario. Any disagreements that appeared were resolved through discussion. The ORCA total score consisted of 16 score points from each of two LESC testlets for a total of 32 possible score

points. The ORCA total score was used as a measure of students' ability to conduct Internet-based research and comprehend the information encountered.

Reliability

Reliability of the ORCA was evaluated using Cronbach's α reliability coefficient, a measure of internal consistency. The combined (32-point) ORCA assessment demonstrated good reliability, with Cronbach's $\alpha = .89$. Reliability was also high for each individual (16-point) LESC assessment scenario: "Energy Drinks" (Cronbach's $\alpha = .83$) and "Asthma" (Cronbach's $\alpha = .79$).

Validity

Validity was established in several ways. First, a framework document was developed and approved by a group of experts in reading comprehension, online research and comprehension, measurement, assessment, science education, and educational research (see tinyurl.com/pe64zbs). This document contained a definition of online research and comprehension and the major elements (LESC). Second, this framework document was used to inform the development of the two ORCAs used in this study through extensive iterations of design meetings and

think-aloud verbal protocols in cognitive labs (Ericsson & Simon, 1999; Willis, 1999) with over 300 seventh-grade students over two years. Third, final decisions about the ORCA score points (see Table 3) were reviewed by a panel of experts in online research and comprehension. Finally, the unidimensionality of the ORCA scale was investigated through principal components analysis. It was found that 78.9% of variance in ORCA scores was explained by the first principal component, indicating that a single composite score should adequately summarize the information in the ORCA assessment.

Internet Use at Home and at School

Students completed a brief questionnaire with two items. The first item asked, “How many computers are in your home that are connected to the Internet?” Possible responses were 0, 1, 2, 3, and 4 or more. Due to sparse data in the upper categories, responses were collapsed into four categories: 0, 1, 2, and 3 or more. Complete responses were obtained from 101 students from West Town and 144 students from East Town.

The second item asked, “How often have you been required to use the Internet at school?” Possible responses were “never,” “less than once a week,” “once a week,” “a few times each week,” and “once a day.” Responses to the second item were collapsed into three categories: never, once a week or less, and more often than once a week. Complete responses were obtained from 100 students from West Town and 142 students from East Town. Validity for these items was established through verbal protocols and cognitive labs with approximately 100 seventh-grade students as well as a thorough review by a team of experts in online research and comprehension.

Administration

An administration protocol for the ORCAs was developed, pilot-tested, and revised before it was used in this study. Two test administrators conducted the assessments in separate classes at the same time, with 25 wireless laptops each. The order of assignment to the research tasks (“Energy Drinks” and “Asthma”) was randomized.

Analyses

Evaluating an Achievement Gap in Offline Reading

The first analysis evaluated whether an offline reading achievement gap existed between mean scores of students from the two districts on the CMT for reading. For this analysis, an independent samples *t*-test was conducted.

Evaluating an Achievement Gap in Online Research and Comprehension

To identify whether there was an achievement gap in online research and comprehension, a second analysis was conducted on the ORCA total score, comparing the difference between mean scores for students in each district. For this analysis, an independent samples *t*-test was conducted.

We also conducted separate independent samples *t*-tests on each LESC component for each research task (“Energy Drinks” and “Asthma”), comparing the difference between mean scores for students in each district. These analyses evaluated whether the online reading achievement gap existed separately in each of the components of online research and comprehension within each research task. Thus, eight tests of mean differences were conducted. To account for multiple comparison issues, *p*-values were computed using a Bonferroni correction for each test. The Bonferroni correction is the simplest and most conservative approach to controlling the familywise error rate (Abdi, 2007). Individual *p*-values and confidence intervals reported in the text are uncorrected. However, as noted in Table 4 in the Results section, all mean differences were statistically significant even after application of the Bonferroni correction. Finally, mean differences were computed with the data collapsed, respectively, across LESC type and research task. Because differences at a lower level of aggregation remained significant after applying a Bonferroni correction, no additional correction for multiple comparisons was necessary for the corresponding *t*-tests.

Evaluating Whether the Achievement Gap in Online Research and Comprehension Persisted After Conditioning on Other Variables

Estimating the Primary Multiple Regression Models

The third analysis evaluated whether an achievement gap in online research and comprehension persisted after conditioning on other possible determinants of ORCA scores. To answer this question, we estimated a multiple regression analysis model that tested for mean differences on total ORCA scores by district, while conditioning on three covariates: scaled scores on the state assessment of offline reading comprehension, total prior domain knowledge of the two topics, and scaled scores on the CMT for writing. We also estimated a separate multiple regression analysis model for each research task (“Energy Drinks” and “Asthma”) to evaluate the consistency of findings across different topic areas, using students who had completed both research tasks.

Evaluating Missing Data

We estimated two additional regression models to evaluate the potential consequences of missing data because of the technology problems that we experienced, especially on the first day of testing. First, we estimated a multiple regression analysis model that tested for mean differences on “Energy Drinks” scores by district, using scores on this assessment from each student who completed it, including those who only completed a single assessment. This model conditioned on three covariates: scaled scores on the state assessment of offline reading comprehension, prior domain knowledge for energy drinks, and scaled scores on the CMT for writing.

Second, we estimated a multiple regression analysis model that tested for mean differences on “Asthma” scores by district, using scores on this assessment from each student who completed it, including those who only completed a single assessment. This model conditioned on the same three covariates: scaled scores on the state assessment of offline reading comprehension, prior domain knowledge for asthma, and scaled scores on the CMT for writing.

Home and School Internet Use Questionnaire Items

Two analyses were conducted on responses to the two questionnaire items, using chi-square tests of association:

1. “How many computers are in your home that are connected to the Internet?”
2. “How often have you been required to use the Internet at school?”

The first evaluated the relationship between home Internet access and the district that a student attended, and the second evaluated the relationship between the frequency of school Internet use and the district that a student attended.

Results

Table 4 presents the means, standard deviations, and Hedges’ g values for the CMT reading score, the total ORCA score for both West Town and East Town students, the total scores for each of the four components (LESC), and the scores for each of the two research tasks (“Energy Drinks” and “Asthma”).

Evaluating the Offline Reading Achievement Gap

Table 4 shows that there was a statistically significant difference in mean scores on the offline reading measure

between students in the two districts: $t(182.75) = 13.81$, $p \leq .001$, 95% confidence interval (CI) [57.86, 77.15]. The estimated magnitude of the difference was large: Hedges’ $g = 1.87$. These results are generally consistent with the results found at the national level, where a large and significant achievement gap in traditional offline reading exists based on income inequality (NCES, 2011b, 2013).

Evaluating the Online Reading Achievement Gap

Comparisons of the online reading measures (see Table 4) revealed a statistically significant difference in mean scores between the districts for the ORCA total score, $t(193.52) = 11.22$, $p \leq .001$, 95% CI [6.06, 8.64]. This also was true for each assessment individually—“Energy Drinks”: $t(205.20) = 7.65$, $p \leq .001$, 95% CI [2.12, 3.59]; and “Asthma”: $t(186.39) = 12.19$, $p \leq .001$, 95% CI [3.77, 5.23]. In all cases, the mean score for students from the economically advantaged district (West Town) was higher. The estimated effect sizes (Hedges’ g) were large: 1.47 for the combined assessment, 0.99 for the “Energy Drinks” research task, and 1.61 for the “Asthma” research task.

In addition, comparisons of the LESL components of the total online reading measure revealed a statistically significant difference in mean scores between the districts for each of the four components: locate total: $t(200.31) = 7.68$, $p \leq .001$, 95% CI [1.53, 2.59]; evaluate total: $t(180.68) = 6.77$, $p \leq .001$, 95% CI [0.71, 1.29]; synthesize total: $t(254.00) = 10.40$, $p \leq .001$, 95% CI [2.08, 3.06]; and communicate total: $t(183.53) = 9.68$, $p \leq .001$, 95% CI [1.35, 2.04]. In all cases, the mean score for students from the economically advantaged district (West Town) was higher. The effect size was large for each component: locate total: Hedges’ $g = 1.00$; evaluate total: Hedges’ $g = 0.90$; synthesize total: Hedges’ $g = 1.31$; and communicate total: Hedges’ $g = 1.29$.

Component mean scores were also significantly different for both “Energy Drinks” and “Asthma,” favoring West Town students in all cases. For “Energy Drinks,” locate: $t(218.10) = 4.44$, $p \leq .001$, 95% CI [0.40, 1.03]; evaluate: $t(191.16) = 3.25$, $p \leq .001$, 95% CI [0.12, 0.49]; synthesize: $t(226.62) = 6.01$, $p \leq .001$, 95% CI [0.671, 1.33]; and communicate: $t(254.00) = 7.50$, $p \leq .001$, 95% CI [0.59, 1.04]. For “Asthma,” locate: $t(254.00) = 8.82$, $p \leq .001$, 95% CI [1.03, 1.66]; evaluate: $t(254.00) = 7.72$, $p \leq .001$, 95% CI [0.51, 0.89]; synthesize: $t(221.58) = 10.20$, $p \leq .001$, 95% CI [1.27, 1.87]; and communicate: $t(254.00) = 8.07$, $p \leq .001$, 95% CI [0.66, 1.11]. The estimated effect sizes (Hedges’ g) for the component scores for “Energy Drinks” ranged from moderate to large: 0.57 for locate, 0.43 for evaluate, 0.76 for synthesize, and 0.94 for communicate. The estimated effect sizes (Hedges’ g) for the component scores for “Asthma” were

TABLE 4
Means (*M*s), Standard Deviations (*SD*s), and Hedges' *g* Values for the Evaluation of Achievement Gap Differences:**
Offline Reading and Online Research and Comprehension

Variable	West Town <i>M</i> (<i>SD</i>)	East Town <i>M</i> (<i>SD</i>)	Hedges' <i>g</i>
State (Connecticut Mastery Test) offline reading scaled score	282.60 (41.54)	215.10 (31.07)	1.87
Online research and comprehension assessment total score (out of 32)	15.00 (5.69)	7.65 (4.39)	1.47
“How Do Energy Drinks Affect Heart Health?” research task (out of 16)	6.91 (3.16)	4.05 (2.64)	0.99
“Can Chihuahua Dogs Cure Asthma?” research task (out of 16)	8.09 (3.25)	3.59 (2.38)	1.61
Locate total (out of 8)	4.47 (2.29)	2.41 (1.86)	1.00
Evaluate total (out of 8)	2.26 (1.32)	1.26 (0.93)	0.90
Synthesize total (out of 8)	5.15 (2.03)	2.58 (1.89)	1.31
Communicate total (out of 8)	3.13 (1.55)	1.43 (1.11)	1.29
“Energy Drinks” component scores:			
• Locate (out of 4)	2.02 (1.32)	1.30 (1.20)	0.57
• Evaluate (out of 4)	1.02 (0.81)	0.72 (0.62)	0.43
• Synthesize (out of 4)	2.37 (1.33)	1.37 (1.29)	0.76
• Communicate (out of 4)	1.51 (1.05)	0.70 (0.68)	0.94
“Asthma” component scores:			
• Locate (out of 4)	2.45 (1.36)	1.11 (1.08)	1.11
• Evaluate (out of 4)	1.24 (0.88)	0.54 (0.56)	0.98
• Synthesize (out of 4)	2.78 (1.25)	1.21 (1.17)	1.30
• Communicate (out of 4)	1.62 (1.04)	0.74 (0.71)	1.02

Note. *N* = 103 (West Town) and 105 (East Town) for offline reading tests and 108 (West Town) and 148 (East Town) for all online reading tests. Both school district names are pseudonyms.

***p* ≤ .001 for all means tests. All means tests were also significantly different when a Bonferroni correction was used.

all large: 1.11 for locate, 0.98 for evaluate, 1.30 for synthesize, and 1.02 for communicate.

Evaluating a Separate and Independent Achievement Gap in Online Research and Comprehension

A multiple linear regression model was used to test whether differences in total ORCA scores by district persisted when we conditioned on pretest differences in CMT reading scores, total prior knowledge scores, and CMT writing scores. To provide context for interpreting the coefficients in the regression model, we first present bivariate correlations between all predictors in Table 5. We then present the regression analysis in Table 6.

Results of the regression model showed that, taken together, school district, CMT reading scores, prior knowledge scores, and CMT writing scores accounted

for 53% of the variance in total ORCA scores (see Table 6). The regression coefficients associated with CMT reading and writing scores were both positive and statistically significant. Interestingly, there was no significant association of prior knowledge scores with ORCA scores when CMT reading and writing scores were accounted for. Similar results were found previously by Coiro (2011).

Our primary interest was to determine whether the mean total ORCA scores, using scores from students who completed both research tasks, were significantly different between the two districts when we conditioned on pretest scores on the CMT for reading, prior knowledge, and the CMT for writing. Conditional on the other variables in the model, students in East Town scored, on average, 2.7 points lower than did students in West Town. We standardized this difference by computing Hedges' *g*, with the adjusted mean difference between districts in the numerator and the unconditional standard deviation of ORCA

TABLE 5

Means, Standard Deviations, and Intercorrelations Among School District, State Reading Scores, Prior Knowledge Scores, and State Writing Scores

Dependent and independent variables with means and standard deviations	1	2	3	4	5
1. School district	—				
2. State reading scores	-.68**	—			
3. Prior knowledge scores	-.12*	.11*	—		
4. State writing scores	-.62**	.77**	.10	—	
5. Total locate, evaluate, synthesize, and communicate score	-.61**	.70**	.030	.62**	—
Mean	0.57	244.31	4.71	252.35	11.08
Standard deviation	0.50	49.11	4.13	41.72	6.09

Note. *N* = 238 across all variables.
p* < .05. *p* ≤ .001.

TABLE 6

Regression Analysis of School District, State Reading Scores, Prior Knowledge Scores, and State Writing Scores on Total Online and Reading Comprehension Assessment (ORCA) Scores for Students Who Completed Two ORCAs

Dependent and independent variables with <i>R</i> ² , <i>F</i> , and <i>n</i>	Total ORCA	“How do energy drinks affect heart health?” research task	“Can Chihuahua Dogs Cure Asthma?” research task
Dependent and independent variables	<i>b</i>	<i>b</i>	<i>b</i>
Total ORCA scores			
School district	-2.70**	-1.60**	-1.39**
State reading scores	.05**	.02**	.01**
Prior knowledge scores	-.09	-.03	.01
State writing scores	.02*	.02*	.02**
<i>R</i> ²	.53	.44	.46
<i>F</i>	65.82**	54.80**	56.20**
<i>n</i>	238	290	303

Note. *b* = unstandardized.
p* < .05. *p* ≤ .001.

scores (pooled across districts) in the denominator. The resulting Hedges’ *g* estimate is 0.54. This achievement gap for online reading cannot be explained by pretest differences between the districts in average CMT reading scores, CMT writing scores, and prior knowledge scores.

Evaluating the Loss of Data

As noted previously, some students were not included in our primary analysis because they only completed one research task due to technological issues. We conducted a secondary analysis that included these data to evaluate the consequences of this loss (see also Table 6). When we conditioned on CMT reading scores, prior knowledge scores, and CMT writing scores for all students who completed the “Energy Drinks” research task and/or the

“Asthma” research task separately, including those students who completed only one of the two, we found that all four predictors, taken together, accounted for 44.2% of the variance in ORCA score for the “Energy Drinks” research task and 46.3% of the variance in ORCA score for the “Asthma” research task. These analyses used a 16-point scale rather than a 32-point scale because the scores from only a single research task were used in each case. Conditional on CMT reading scores, prior knowledge scores, and CMT writing scores, students in East Town scored, on average, 1.60 (out of 16) points lower than students in West Town for “Energy Drinks” and 1.39 (out of 16) points lower than students in West Town for “Asthma.” Both mean differences were significant (*p* ≤ .001). Hedges’ *g* was moderate in size for both “Energy

Drinks” (0.52) and “Asthma” (0.54). These estimates for an achievement gap in online reading based on income inequality cannot be explained by pretest differences between the districts in average CMT reading scores, CMT writing scores, and prior knowledge scores.

Evaluating the Consequences of Gender Differences Between Schools

As noted previously, there was a difference in the gender distribution between the two schools (58 girls and 50 boys in West Town and 67 girls and 80 boys in East Town, with gender data missing for one student from East Town). National assessment results (NCES, 2013) indicate that boys tend to perform less well than girls on literacy assessments. As a result, we were concerned that the gender distribution in this study may have affected the results, depressing the overall mean ORCA score for East Town students, compared with West Town students. Thus, we also estimated an additional regression model that conditioned on gender as well as on pretest differences in offline reading scores, offline writing scores, and prior knowledge scores.

These results showed little difference in the coefficient for school district even when gender was included in the model ($b = -2.69$), compared with the model without gender ($b = -2.70$). Thus, adding gender to the model resulted in no appreciable change, with students in East Town still scoring an average of 2.7 points lower than students in West Town.

Home and School Internet Use Questionnaire Items

Tables 7 and 8 present responses to the two questions about online access at home and at school for West Town and East Town students. Results indicate that East Town students

had less access to computers at home than did West Town students, and this difference in access was statistically significant. Furthermore, East Town students were also more likely than West Town students to never have been required to use the Internet at school. Differences were again statistically significant.

Discussion

Do national assessments such as NAEP underestimate the reading achievement gap in the United States, based on income inequality, since they only measure offline reading skills? This issue is important because online reading has become an increasingly central aspect of life in an online age (Pew Research Center, 2014) and because we are experiencing growing income inequality in the United States (Congressional Budget Office, 2007), an increasing gap in reading achievement (Bailey & Dynarski, 2011; Reardon, 2011, 2013), and a decline in social mobility (Chetty et al., 2014). Having a portion of any society underprepared for literacy in an online age limits opportunities for both individuals and the nation.

Evaluating the Achievement Gap in Offline Reading Comprehension

Consistent with national results (NCES, 2011b, 2013), data analysis in our sample found a large achievement gap in offline reading comprehension between seventh-grade students attending an economically advantaged school and those attending an economically challenged school. The achievement gap reported in our data is generally consistent with national data for offline reading achievement gaps (e.g., NCES, 2011b, 2013; Reardon, 2011).

These results indicate that the offline reading test scores of the seventh-grade populations in these schools

TABLE 7
Responses to the Survey Question “How Many Computers Are in Your Home That Are Connected to the Internet?”

School district	0	1	2	3 or more	Total
West Town	1 (1.0%)	15 (14.9%)	23 (22.8%)	62 (61.4%)	101
East Town	12 (8.3%)	45 (31.3%)	39 (27.1%)	48 (33.3%)	144

Note. $\chi^2 = 23.392$, $df = 3$, $p = .0003$. The percentages total 100.1% because of rounding.

TABLE 8
Responses to the Survey Question “How Often Have You Been Required to Use the Internet at School?”

School district	Never	Once a week or less	More often than once a week	Total
West Town	4 (4.0%)	52 (52.0%)	44 (44.0%)	100
East Town	35 (24.6%)	55 (38.7%)	52 (36.6%)	142

Note. $\chi^2 = 18.665$, $df = 2$, $p = .0005$. The percentages total 99.9% because of rounding.

appeared to represent a reasonable sample with which to test for a separate online research and comprehension achievement gap. The differences between students in the two districts were large and significant and matched the differences found at the national level reasonably well between students in economically advantaged and challenged school districts. Noticeably, though, the sample did not use the most extreme DRGs and, thus, did not test the true extremes of economic circumstance between school districts.

Evaluating the Achievement Gap in Online Research and Comprehension

We also wanted to evaluate whether income inequality was associated with online reading achievement. It was. Mean ORCA total scores were nearly twice as great for students attending West Town (15.00) as they were for students attending East Town (7.65), with a large effect size (Hedges' $g = 1.47$).

The achievement gap in online reading was robust, appearing in mean comparisons of scores for students in the two districts for each of the four major skill areas, for each of the two research tasks, and for each of the four major skill areas in each of the two research tasks (see Table 4). Hedges' g estimates for these comparisons ranged from 0.43 to 1.31, which are generally considered moderate to large effect sizes.

Evaluating a Separate and Independent Achievement Gap for Online Research and Comprehension

Currently, we define reading achievement gaps based on students' ability to read offline information (cf. NCES, 2011b, 2013; Reardon, 2011). This study found an additional and separate achievement gap based on income inequality for online reading among students who completed both research tasks. A significant achievement gap in online research and comprehension persisted when pretest differences in the most likely predictors of success in this area were conditioned for in the analyses: CMT reading scores, prior knowledge scores, and CMT writing scores. After conditioning on all variables, students in East Town scored, on average, 2.7 points lower on online research and comprehension compared with students in West Town. The effect size associated with this difference was .54. This separate and independent achievement gap for online reading appears to be an important one. If the separate effect size difference found in this study can be related to those on nationally normed assessments in reading reported by Hill and colleagues (2008), it appears to represent more than one additional year of annual growth at the middle school level beyond that reported for offline reading.

It has become common to interpret effect sizes in the social sciences using labels proposed by Cohen (1988). Effect sizes of .20, .50, and .80 are considered small, medium, and large, respectively. However, Cohen has stated that these suggestions were "for use only when no better basis for estimating the [effect size] index is available" (p. 25).

Hill and colleagues (2008) provide precisely this "better basis" for interpreting effect sizes related to educational achievement. Their work shows the annual reading growth in average test scores obtained across seven nationally normed, vertically scaled tests. In effect size units, the annual growth in the middle school years is between .12 and .44. Given that an entire year of schooling along with other developmental growth that students experience in the middle school years result in an effect size no greater than .44, it seems fair to call effect sizes in the .3–.5 range large in the context of educational achievement data.

Furthermore, Rutledge and Loh (2004), Breaugh (2003), and others remind us that effect size estimates must be flexibly interpreted. Even a small effect size on an important issue such as mortality remains important and should not be ignored. One might argue that this is also the case for the results found in this study, which suggest that we currently underestimate reading achievement gaps by at least an additional year of schooling in the United States by failing to include the reading demands required during online research and comprehension.

The results of this study are important to consider in relation to the U.S. Department of Education's (2010) goal to close the achievement gap so all students graduate from high school ready to succeed in college and their future careers. The results suggest that an additional online reading achievement gap exists. Thus, the challenge in reading is substantially greater than we currently recognize, and public policies also will need to change accordingly. As nations often seek to fulfill egalitarian principles through their educational systems, an additional online reading achievement gap should be a concern (cf. Hatlevik & Gudmundsdottir, 2013). This is especially important because it appears likely that online research and comprehension will be an increasingly important part of our students' futures.

Lack of opportunity in every nation is important to consider. Piketty (2014) has recently argued that rising income inequality is rapidly taking place in both the United States and on a global basis as the rate of return on capital has exceeded the rate of economic growth. The fact that the 85 richest people in the world have acquired as much wealth as the poorest half of the entire world's population (Credit Suisse, 2013) seems to confirm this observation. Most importantly, Piketty suggests that if unchecked, this increasing inequality could lead to deep political and social disruption.

Evaluating Data Loss

Concerned about the loss of data among students who only completed a single research task because of technological issues on the first day of testing, we evaluated the main question of interest with separate regression models for all students who completed either “Energy Drinks” or “Asthma.” Three patterns from this analysis suggested that excluding these students from the primary analysis did not affect the results. First, even though the scale for the possible ORCA score in the secondary analyses (0–16) was only half that of the primary analyses (0–32), the percentage of variance accounted for by all variables in the single-task models (44.2% for “Energy Drinks” and 46.3% for “Asthma”) was similar to that of the dual-task model (53% for “Energy Drinks” and “Asthma” combined). Second, after conditioning on all variables, the mean difference scores for all students who completed the separate research tasks, “Energy Drinks” (1.6 out of 16) and “Asthma” (1.4 out of 16), when combined, matched closely the mean difference score for students who completed both “Energy Drinks” and “Asthma” (2.7 out of 32). In fact, it was slightly higher (3.0 compared with 2.7). Third, Hedges’ g estimates for these mean differences were all similar: For students who completed both “Energy Drinks” and “Asthma,” Hedges’ $g = 0.54$; for all students who completed only “Energy Drinks,” Hedges’ $g = 0.52$; and for all students who completed only “Asthma,” Hedges’ $g = 0.54$. We concluded from these supplemental analyses that data loss did not substantially affect the primary results.

Cautions

We urge some caution in interpreting the results of this study for several reasons. First, it used a purposive convenience sample of two school districts in one state, selected carefully to ensure income differences between districts. Although the results suggest that a separate and independent achievement gap exists in online research and comprehension based on income inequality, it is important to investigate this issue with larger populations and in more states. Currently, we are unable to do so because the NAEP (NCES, 2013) does not include any skills related to online research and comprehension. This study suggests that it should, especially if the United States is committed to educational opportunity for all students in an online age of information.

In addition, it is important to note that this study used an economic indicator of school communities as a whole (e.g., DRG) to identify students, not an economic indicator for individuals (e.g., individual family income or individual eligibility for free or reduced-price lunch). Previous work with offline reading achievement gaps (NCES, 2011b; Reardon, 2011) used economic indica-

tors for individuals, which may have been more sensitive to any differences.

Third, the two districts selected in our convenience sample did not contrast the most extreme economic levels of our national population. The state where our study took place is ranked within the top four states in relation to U.S. median family income (Noss, 2012). In addition, our economically challenged district had a median family income of nearly \$60,000, whereas the official poverty threshold in the continental United States is currently at \$24,028 for a family of four (U.S. Census Bureau, 2013). The difference between our sample and the extremes of income in the United States is not inconsiderable. Moreover, the number of students affected by these extremes is large. In 2012, 21.8% of children under age 18 lived below the poverty line, nearly a quarter of the children in the United States (Noss, 2012). Our results are perhaps better construed as an exploration of the achievement gap between the privileged and the middle class, and results may not be representative of gaps between children of upper class families and children living in poverty. The fact that the cost of living in Connecticut is greater than most other states (Missouri Department of Economic Development, 2014) may somewhat mitigate this concern. Nevertheless, it is likely that the gap observed in this study would have been even greater had we compared students from groups with more pronounced differences in income.

Student Performance Levels

Having noted these concerns, it is important to observe that students in both districts performed at a low level during these online research and comprehension tasks. West Town students were able to respond correctly to ORCA items only about half of the time and East Town students only about 25% of the time. This represents very low mean levels of proficiency with online research and comprehension, and it raises an important concern about student preparedness for learning from online information at the seventh-grade level. The lowest areas of component performance appeared in evaluation (mean = 1.68 out of 8, or 21% correct) and communication (mean = 2.15 out of 8, or 27% correct). These two areas may be especially important to consider for instruction in schools.

It is also important to note that an avatar student guided students through the research task, so these were not completely independent online research tasks. As a result, one might expect an independently structured online research task, perhaps more typical of many classrooms, to generate even lower levels of performance. If these levels characterize performance levels for online research and comprehension among students at other schools, it should be a fundamental concern for both policy and instruction. Increasingly, reading will take

place online (OECD, 2010), and inquiry reading will be central to learning (Goldman et al., 2012). Students who are only able to successfully complete less than 50% of the tasks required for successful online research and comprehension on their own will be tremendously underprepared for the future.

The fact that students in both school districts did not perform at higher levels with online research and comprehension may be surprising to some who consider this generation to be “digital natives” (Prensky, 2001, p. 1). Although today’s students grow up in an online world and are developing skills in gaming, social networking, video and audio downloading, and texting, this does not mean that they are necessarily skilled in online information use. Indeed, research is showing how limited students’ skills are in this area, including locating information online (Bilal, 2000; Guinee et al., 2003; Kuiper & Volman, 2008) and critically evaluating it (Walraven, Brand-gruwel, & Boshuizen, 2008). Many students find it difficult to judge the accuracy, reliability, and bias of information that they encounter during online research (Bennett, Maton, & Kervin, 2008; Graham & Metaxas, 2003; Sanchez et al., 2006; Wallace, Kupperman, Krajcik, & Soloway, 2000). In fact, adolescents tend to overgeneralize their ability to read online information effectively, informed by their ability to engage successfully with online social networking, texting, and video games (Kuiper & Volman, 2008). Previous research, as well as the results of this study, suggest that instruction in online research and comprehension is important to include in the literacy curriculum, especially as reading continues to shift from page to screen and online information use, inquiry, and problem-based learning become increasingly important to learning (OECD, 2010).

Interpreting These Results in Relation to Public Policies: Standards, Curriculum, and New Assessments

Online research and comprehension skills are just beginning to be recognized in the literacy curriculum in several nations, including Australia (Australian Curriculum, Assessment and Reporting Authority, n.d.), Canada (Minister of Manitoba Education, Citizenship and Youth, 2006), and the United States (NGA Center & CCSSO, 2010). An important design principle of the Common Core State Standards of the United States (NGA Center & CCSSO, 2010) identifies these skills as a new and important component:

To be ready for college, workforce training, and life in a technological society, students need the ability to gather, comprehend, evaluate, synthesize, and report on information and ideas, to conduct original research in order to answer questions or solve problems, and to analyze and create a high volume and extensive range of print and nonprint texts in media forms old and new. The need to conduct

research and to produce and consume media is embedded into every aspect of today’s curriculum. (p. 4)

Unfortunately, these online research and comprehension skills are never explicitly stated in the Common Core’s Anchor Standards for Reading; the words *Internet* and *online* do not appear in any of them (Leu et al., 2011). The failure to explicitly identify online research and comprehension skills in the Reading Standards raises an important question: Will schools recognize the changes to reading taking place on their own accord and integrate the Internet and online research and comprehension skills into the literacy curriculum when specific standards in reading do not expressly indicate to do this? Perhaps some states will take advantage of the opportunity to revise up to 15% of the Common Core’s Reading Standards, include online research and comprehension skills, and still remain a Common Core state (see Kendall, Ryan, Alpert, Richardson, & Schwols, 2012). States could, for example, alter the Common Core’s Reading Standards and more explicitly define an online reading context by including phases such as “on the Internet” or by including additional skills, such as critically evaluating the reliability of online sources. Drew (2012) provides specific suggestions for doing so, making online research and comprehension skills more visible in the Common Core’s Reading Standards.

It also remains to be seen whether items in the new assessments for the Common Core (NGA Center & CCSSO, 2010) will adequately represent the domain of online research and comprehension. It would be easy, for example, to include a single online research and comprehension task in these assessments. During a period when we increasingly read online to conduct research and learn, a single task may not be adequate for representing the domain, especially when so many new online tools for research and communication have been appearing. Should new assessments include more than a single online research and comprehension task, it is also not yet clear whether online research and comprehension should be combined on a single scale with offline reading or represented on a separate scale to more precisely chart the development of online research and comprehension skills. Recent work showing the benefits of collaborative online research and comprehension (Kiili, Laurinen, Marttunen, & Leu, 2012; Passig & Maidel-Kravetsky, 2014) also raise the concern that ORCAs will need to evaluate students’ ability to conduct collaborative online research.

Some might think that the rapid shift to online assessment that is taking place (Gewertz, 2012) will solve the problem raised by this study. It does not. It is important to recognize that because reading assessments now appear online does not mean that they necessarily measure online reading ability. Simply placing assessments online, with items derived from offline assessments, does nothing to

measure students' ability to conduct online research and comprehend. New online assessments of reading will require an adequate number of online research and comprehension tasks. In addition, another issue should also be considered: Will assessments in social studies, science, math, and other areas also include online research and comprehension tasks, which appear to be impacted by income inequality? Online research and comprehension is important to learning across all disciplinary areas, in addition to reading.

These issues are important to consider because economically challenged districts are often under the greatest pressure to raise test scores and may focus limited resources on instruction that maps precisely to standards and assessments in an attempt to increase student performance. Until and unless online research skills are more visible in both standards and assessments, economically challenged schools may be less likely to incorporate them into their curriculum.

This is not to say that this approach is desired; it is, though, a recognition of the realities that currently exist with such a heavy emphasis on testing in our classrooms (Darling-Hammond, 2004). It is also a recognition of the potential consequences that may result from decisions about what and how to evaluate students with high-stakes assessments. With little indication of online reading, the potential exists for standards and assessments to increase, rather than decrease, the achievement gap in online research and comprehension. Economically challenged, and often lower performing, schools may be more likely to focus on the explicit formulation of reading standards, interpret them in an offline context, and thus fail to integrate online research and comprehension skills into instruction.

This may have happened in the schools used in this study, although there is only tentative evidence to suggest this possibility. Students in the two districts reported a significant difference in response to the question "How often have you been required to use the Internet for a school assignment?" Only 4% of students in West Town responded that they had never been required to use the Internet at school, while 25% of students in East Town indicated that they had never been required to do so, even though East Town had a better ratio of students to instructional computers with Internet access in the middle school (3.3) compared with West Town (3.7). Notably, none of the state standards for these schools, in place during the study, included reading in online contexts.

Although these data only show correlation, not causation, it would be ironic, indeed, if national standards and assessments, designed to close achievement gaps, end up increasing the achievement gap in online research and comprehension because they fail to adequately represent the new social practices, skills, and strategies that are important to reading in an online age. Of course, an alternative future is also possible, one in which we prepare

students for online reading and learning, creating a future in which new insights, new ideas, and new futures are made possible by teachers who thoughtfully integrate online research and comprehension into the literacy curriculum.

NOTES

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