Supporting middle school students’ online reading of scientific resources: moving beyond cursory, fragmented, and opportunistic reading

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Abstract
The abundant scientific resources on the Web provide great opportunities for students to expand their science learning, yet easy access to information does not ensure learning. Prior research has found that middle school students tend to read Web-based scientific resources in a shallow, superficial manner. A software tool was designed to support middle school students in reading online scientific resources through three key strategies: making explicit a skim–read–summarize structure for online reading, using prompts to guide students’ reading and foster articulation of thinking, and connecting reading to learning purposes. This study examined the differences between regular and guided online reading performed by eight pairs of sixth graders in a science inquiry project. The students’ online reading processes and conversations were captured by a screen-recording programme. Analysis of 60 h of screen videos showed that the students’ online reading in the regular condition was cursory, fragmented, and opportunistic, while the structured online reading was more deliberate, thorough, and purposeful. Overall, the results suggest that middle school students’ online reading of scientific resources needs to be guided.

Keywords
information literacy, online learning, pedagogy, science education, technology-based scaffolding strategies, Web-based resources.

Introduction
Web resources have been widely used in K-12 schools in recent years, thanks to easy access to the Internet and the abundance of online resources (Kuiper et al. 2005; Wells & Lewis 2006). In particular, Web-based scientific resources offer great opportunities to science education by providing rich, engaging, updated, and readily accessible information. Nowadays, students consider the Web, rather than libraries, as their first-choice resources for their school projects (NetDay 2004). Many teachers also reported that use of Web resources helped them meet state and federal standards in science, technology, engineering, and mathematics education (Hanson & Carlson 2005).

Despite the potential prospects of online resources, however, science learning on the Web is hard to promote. After all, as Colaric and Jonassen (2001) noted, ‘Information does not equal knowledge, searching does not equal learning, and hyperlinking is not good instruction’ (p. 159). Prior research has shown that it is difficult for middle school students to evaluate online information and read to develop meaningful learning with online scientific resources.
Wallace et al. (2000) studied sixth-grade students’ use of online resources in science learning and found that these students focused on finding a ready-made answer to their question by quickly skimming websites, rather than reading to understand the science content. These students appeared very busy online, but their ‘busyness’ had little to do with learning. They also tended to accept what was on screen as truth. Their teacher was occupied with managing the lab and providing technical help to students.

In addition, Kuiper et al. (2009) found the fifth-grade students in their study held a view that ‘on the Web you don’t need to read’ (p. 676). Reading online resources for an inquiry project about healthy food was difficult for them because of their lack of patience. Most students stayed close to the homepage or clicked at some links without reading the content. In addition, Kuiper et al. (2009) found that the students rarely evaluated the credibility of the information they found. The teachers in their study seemed to be unaware of students’ needs for guidance in online reading. They focused on developing students’ search skills, but paid little attention to critical evaluation and reading skills.

Other researchers have identified a similar problem of superficial engagement with content in online reading and lack of evaluation skills (Eagleton & Guinee 2002; Sutherland-Smith 2002; Coiro 2003; Hoffman et al. 2003). Students tend to go through web pages quickly without stopping to read. They often make hasty choices with little thinking in their online reading. Coiro (2003) noted that ‘These shallow, random, and often passive interactions with text are in direct contrast to the active, strategic, and critical processes of constructing meaning now being proposed by instructional leaders and supported by 25 years of reading research’ (p. 458).

In sum, prior research has shown that students need support and guidance in online reading (Ruthven et al. 2005; Kuiper et al. 2009). Yet, relatively few design efforts have been made to help students go beyond superficial, shallow engagement with online resources. Moreover, much of prior research occurred in a controlled setting, in which the researchers designated questions for students to search online within a short period of time. Studies focusing on authentic inquiry projects that are driven by students’ interests remain limited. This study aimed to fill in the gap by exploring technology-based strategies to support middle school students in reading online scientific resources in a real-world classroom inquiry project.

**Design of a digital notepad and guiding strategies**

We designed a software tool called IdeaKeeper (School of Education, University of Michigan, Ann Arbor, MI, USA) to support students’ online learning through inquiry planning, information search, analysis, and synthesis (Zhang & Quintana 2012). While IdeaKeeper attempts to support the full range of Web-based inquiry activities, supporting reading and sense making is the most important goal because reading is essential to the success of online learning. Specifically, within the software tool, a digital notepad was designed to support students’ online reading. The notepad design was guided by the following strategies.

**Strategy 1: making explicit a skim-read-summarize structure for online reading**

How to approach online scientific resources is implicit for many middle school students, which might explain their superficial engagement with content in online reading. Quintana et al. (2004) proposed a software design framework to support science inquiry in which one of the strategies was to make tacit disciplinary thinking explicit in tools and help learners understand the steps they need to undertake in their work, thus making thinking visible (Lin et al. 1999).

Building on the ideas of Quintana et al. (2004), IdeaKeeper highlights an implicit process involved in reading and making sense of online information: skimming, reading, and summarizing (Brozo & Simpson 2002; Schmar-Dobler 2003). IdeaKeeper displays websites in a browser window framed by a notepad (Fig 1), which describes the ‘skim–read–summarize’ steps. Students are first directed to the *Skim* tab, where they see criteria for evaluating the relevance, credibility, and quality of the website with respect to their research goals. Students then move to the *Read* tab where they answer different questions about the website content as they read it. Finally, students move to the *Summarize* tab where they summarize what they have learned from their reading. Notepads are attached to every website that students open within the browser window. Having an explicit skim–read–summarize structure helps students anticipate what they need to do when approaching...
a website, which might help them move beyond their superficial approach to reading online resources and deepen their engagement with content.

Strategy 2: using prompts to guide students’ online reading and foster articulation of thinking

Prior research has shown that prompts can enhance students’ reflection in science inquiry (Davis 2003). Prompts were incorporated in the notepad to guide students in reading and analysing websites. These prompts describe to students what to think about, look for, and articulate as they skim (left side of Fig 1), read (middle of Fig 1), and summarize (right side of Fig 1) the resource.

First, skilled readers do not simply jump into a text and start reading immediately, but rather they try to skim the main features of a text, such as its title, introduction, headings, subheadings, visuals, and bullet lists, to get an overview of the text, and to understand what might be the important parts with respect to their reading goals (Pressley & Afflerbach 1995). Online reading also involves critical evaluation of websites for trustworthiness and usefulness. To help students to learn strategies for skimming and evaluating a website, the skimming tab in the notepad prompts students to think of the following questions: (1) Is this website related to my question? (2) Is this website easy to read? (3) Is the information on this website up-to-date? (4) Is the information on this website fact or opinion? (5) Are the pictures or animations helpful or distracting? (6) Might the author be biased by presenting this information this way? (7) Does the author know what he or she is talking about? (8) How much do I trust this website? and (9) Is this website worth reading? These categories represent important aspects of evaluating a website (Julien & Barker 2009; Walraven et al. 2009).
If students decide that a website is worth reading, they can click the reading tab in the notepad to take notes for their research question. While the skimming tab focuses on a general view of the website, the reading tab focuses on a more in-depth view, where students identify ideas, evidence, and specific content that can shed light on the question they are investigating. There are six questions embedded in the reading tab. The first prompt, *what is the main idea of the web page*, asks students to identify important information in a website. Students often mistake what is interesting for what is important. They may become lost in details rather than trying to make sense of the text as a whole (Farstrup & Samuels 2002). Therefore, it is important to ask students to focus on important information. The second question, *what evidence does the author give to support the main idea*, asks students to identify an evidence–claim structure. The core of scientific thinking is to use evidence to support or refute a claim (Toulmin 1958). To break the tendency for students to simply accept what is said (Walraven et al. 2009), it helps to ask students to identify evidence for the scientific claim in a resource.

The third question, *what information in the web page helps me answer my questions*, links what is being read to the research question. Reminding students of their purpose helps them concentrate on finding and taking note of the most important information that will meet the established goal (Pressley & Afflerbach 1995). The fourth question, *what information in this web page is difficult to understand*, asks students to monitor their reading comprehension, being aware of what they know and do not know. The fifth question, *what points does this author make that other authors do not*, asks students to compare and contrast the websites they read and to pay attention to different features in each website. The last prompt, *what is other relevant information*, allows students to record information they think is worth noting and is not covered by the questions mentioned earlier. This question gives students flexibility to record information of their interest.

Finally, readers go to the summarizing tab to sum up what they have learned in the website. There is only one question in this tab, *what did I learn from this website?* Students can write what they have learned from reading the web pages and what information may be useful for answering their question. When they summarize, students can refer to the notes they have taken in the reading tab. Prior research has found that summarizing can enhance text comprehension and learning retention (Palincsar & Brown 1984).

**Strategy 3: connecting reading to learning purposes**

Skilled readers process text with a clear purpose in mind (Ciro & Dobler 2007). Awareness of reading goals directly influences the processing of text. It affects a reader’s decision about what are important parts in the text, what to read and in what order, which parts to read carefully, which parts to skim only, and which parts to skip. Thus, bearing in mind a clear goal helps students to read purposefully and selectively, to focus and sustain their learning efforts, and to monitor and regulate their processes. However, middle school students often read without a clear purpose in mind (Block & Pressley 2002). They tend to consider ‘all the material is important’, treating each part of a text as equally important and paying equal attention to different text, a characteristic of less competent reading (Brozo & Simpson 2002). Research on reading has well documented the importance of establishing a clear purpose for reading (Palincsar & Brown 1984; Pressley & Afflerbach 1995).

Purposeful reading is particularly important in online environments. Because of the interactive and open-ended nature of hypertext, students have to make frequent decisions about where to go and what to do. Stimson (1998) noted that a hypertext learning environment provides more user control than traditional text, thus requiring more self-monitoring and control. Furthermore, in online environments, students can easily be distracted by appealing but irrelevant multimedia materials, such as images, sounds, movies, and animations. Also, different reading purposes demand different levels of mental efforts (Narvaez et al. 1999; Zhang & Duke 2008). Zhang and Duke (2008) studied 12 skilled adult Internet readers and found these readers adjusted their strategies for different reading purposes. The authors suggested that it is important to teach novice Internet readers to ‘be aware of their purposes for Internet reading’ (p. 128).

In the planning space of IdeaKeeper, students input their learning goals that drive their online search. To help students stay focused, students’ learning goals are always presented at the top of the notepad to help students keep their goals in mind when they browse web
pages. In addition, the prompts in the notepad help students to assess whether the information is relevant to their research question and what information they find in the website can help them answer their research question. Students can also easily go back to the planning space to check their question and subquestions whenever they need to.

This study aimed to explore how the technology-implemented strategies described earlier can support middle school students in online reading. Specifically, this study examined the following questions: How did middle school students read scientific resources on the Web, and how was their reading mediated by the supporting strategies?

Method

Context

This study took place in two sixth-grade classrooms at a public middle school in Ann Arbor, MI, USA, when students conducted online research for a science project. The entire project lasted about 4 weeks, in which students used computers for about 2 weeks to do online research. Four pairs from a sixth-grade class used IdeaKeeper for their online research project, referred to as the IdeaKeeper group, and another four pairs from a different sixth-grade class taught by the same teacher used the Google search engine only, referred to as the Google group. Both groups had equal access to online resources and had worked on the same science topic on water, as the students were learning a unit of hydrology. The IdeaKeeper students used the digital notepad to take notes, while the other group used their paper notebooks.

For the online research project, the teacher asked students to generate a driving question and three subquestions about water and then search for information online. Their final task was to write an essay and create a brochure to demonstrate their understanding about the driving question. Both groups spent about 2 weeks working in the computer lab. During the lab time, students worked in pairs to find information on the Web for their driving questions. The teacher sometimes stopped students and led a whole-class discussion. The teacher had taught 11 years at the middle school level. Pseudonyms were used for the teacher and students.

Participants

Sixteen students from two sixth-grade classes (ages 12–13) participated in this study, including 11 Whites, four Asians, and one African-American student. Students were paired by the teacher based on the similarity of their driving questions. Because the teacher was familiar with her students, she helped to select the student participants from each class to form two comparable groups, with a consideration of matching gender and achievement levels for the two groups. These students were informed of the purposes and the processes of this study. Consent forms were obtained from these students and their parents. Table 1 describes the backgrounds of the student participants and their driving questions.

Data collection

The students’ computer activities and conversations were recorded by Camtasia, a screen-capturing programme by TechSmith, Okemos, MI, USA. The Camtasia videos were the primary data sources for this study. The IdeaKeeper group spent nine lab sessions finishing their online research, 40–50 min per session, and the Google group spent 11 sessions. The fact that the Google students needed two more sessions was mainly because of the inefficiency involved in their online research processes. For example, the Google students had to record URLs and other notes manually, while IdeaKeeper allowed the students to save information automatically. A total of 80 Camtasia videos were collected from the eight pairs (4*9 + 4*11 = 80), representing about 60 h of videos. The computer screens were captured with high resolutions, so the text in the video was easily readable.

Data analysis

First, all of the Camtasia videos that were collected from the two groups were transcribed. The detailed transcripts documented the students’ computer activities, as well as their verbal conversations. The videos were segmented according to the major events, including searching, skimming, reading, reviewing notes, monitoring, offline work, off-task, and the teacher’s instruction. An analysis of how the two groups engaged in the whole range of online inquiry activities differently was reported.
elsewhere (Zhang & Quintana 2012). This study focused on analysis of students’ online reading patterns.

First, two distinct types of online browsing were identified: skimming and reading. Skimming was defined when students quickly scrolled a web page to gain a cursory view of the content without looking into the text in detail. When skimming, students usually spent less than 30 s on a site, sometimes even less than 10 s. Skimming mainly served the purpose of determining whether a site was related to one’s question. If so, students would read the site. Otherwise, they would quit the site and return to the search hits. Students then either opened another site from the hits to browse or conducted a new search. Therefore, reading was defined when students read at least some words or sentences on a site and usually spent longer than 30 s on the site. Students could hardly develop any content understanding when skimming a site. They might develop some content understanding from reading a site, depending on how serious the reading was. Analysis was conducted on how the students in both groups spent time skimming and reading websites.

Second, to understand how serious the students’ reading was, their reading was further differentiated in terms of fragmented or thorough levels, which was determined by the patterns shown in the majority of the websites that they read rather than skimmed. Their reading was considered fragmented, if for the majority of websites they read only a few words on a web page, without reading complete sentences; somewhat fragmented if they read several sentences, or one to two paragraphs on a web page; and thorough if they read the majority of the content in the website, typically involving three paragraphs or more.

Third, analysis was conducted on how the students approached websites, in terms of what elements on a website that they paid attention to and in what order. Such analysis helped to understand whether guided online reading was more purposeful than regular online reading. The students’ reading was considered opportunistic if for the majority of websites that they read, their attention jumped to different elements of a web page without clear logical connections and with little consideration of their learning goals. Their reading was considered purposeful if for the majority of the websites that they read, their reading was guided by their driving questions. Their reading was considered somewhat opportunistic if they demonstrated opportunistic reading for some websites, but purposeful for a few others.

It should be noted that the students’ computer screen activities and the conversations between partners provided sufficient information for researchers to track their focal points. For example, when the students read a web page, they often moved their mouse cursor along the text and talked to their partner about what they thought. The design of having the students to work in pairs prompted

<table>
<thead>
<tr>
<th>Group</th>
<th>Pair</th>
<th>Name</th>
<th>Gender</th>
<th>Achievement level</th>
<th>Driving question</th>
</tr>
</thead>
<tbody>
<tr>
<td>IdeaKeeper</td>
<td>Pair 1</td>
<td>Dane &amp; Abby</td>
<td>Boy–girl</td>
<td>Medium–high</td>
<td>How does acid rain affect the quality of our water?</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>Clay &amp; Gwen</td>
<td>Girl–girl</td>
<td>High–high</td>
<td>Why are countries allowed to dump raw sewage in the ocean?</td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>Ferris &amp; Edna</td>
<td>Boy–girl</td>
<td>Medium–medium</td>
<td>What should we do about 1,4 dioxane in Ann Arbor’s groundwater?</td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>Dylan &amp; Bona</td>
<td>Boy–girl</td>
<td>Medium–medium</td>
<td>How does a combination of groundwater and surface water affect the quality of Ann Arbor’s drinking water?</td>
</tr>
<tr>
<td>Google</td>
<td>Pair 5</td>
<td>Gordon &amp; Jennifer</td>
<td>Boy–girl</td>
<td>High–high</td>
<td>What causes dead zones? What is a ‘dead zone’?</td>
</tr>
<tr>
<td></td>
<td>Pair 6</td>
<td>Grace &amp; Fiona</td>
<td>Girl–girl</td>
<td>High–high</td>
<td>Why are water-borne diseases more prone to some places than others? How are water-borne diseases spread?</td>
</tr>
<tr>
<td></td>
<td>Pair 7</td>
<td>Kale &amp; Irvin</td>
<td>Boy–boy</td>
<td>Medium–medium</td>
<td>Why is the ocean salty? Why is there salt in the ocean?</td>
</tr>
<tr>
<td></td>
<td>Pair 8</td>
<td>Hart &amp; Faye</td>
<td>Boy–girl</td>
<td>Medium–medium</td>
<td>How does the filtration system work? Can we filter our own waste into usable drinking water?</td>
</tr>
</tbody>
</table>
them to think aloud naturally, which allowed researchers to understand their thinking processes.

Results

First, a summary of the findings is presented, followed by details and evidence in the next sections. Data analysis showed that unguided online reading tended to be cursory, fragmented, and opportunistic, consistent with what has been reported in prior research. The Google students tended to browse websites quickly, but rarely stopped to read the content of a website to gain understanding. Their reading was not only cursory, but also fragmented and disconnected. Typically, they scrolled up and down a web page and picked up some keywords and sentences that drew their attention. Moreover, their reading was opportunistic as their temporary interest shifted frequently among different elements of a site. Pictures and animations, regardless of their relevance, were more likely to attract their attention. In contrast, guided online reading was more deliberate, thorough, and purposeful. The IdeaKeeper students spent much longer time reading the sites that they considered relevant. They were also more likely to read the content of a site to develop understanding. Structured by the IdeaKeeper notepad, the students focused on finding information to answer their research questions, regardless of whether the information was text or images.

The differences in their reading patterns reflect three different aspects of online reading: (1) cursory/deliberate reading refers to the time students spent reading a site; (2) fragmented/thorough reading refers to the amounts of information that students read and the completeness of the information being read; and (3) opportunistic/purposeful reading refers to the sequence in which students read information. These patterns are interconnected. Because their online reading was often cursory, the Google students tended to read some fragmented words or sentences, rather than reading more thoroughly. Not surprisingly, the shorter time students spent on a site, the less text they could read. Moreover, the fragmented reading was also related to the opportunistic reading. Because the students often did not wait until they finished reading one paragraph or even one sentence to jump to other parts of a website, their reading was inevitably fragmented. Next, the three findings are discussed in detail.

Cursory versus deliberate reading

Data analysis showed that regular online reading was more cursory than the guided online reading. On average, the Google students spent 299 min online in the 11-day online research period, and the IdeaKeeper students spent 256 min online in the 9-day period. On average, the IdeaKeeper students spent 49% of their total online time reading nine websites and 6% of time skimming 35 websites, while the Google students spent 31% of their total online time reading 26 websites and 13% of time skimming 78 websites.

On average, the IdeaKeeper students spent 28 min online per class session and the Google students spent 27 min. The remaining class time was used either by whole-class discussion or offline work. To facilitate comparison, the students’ online activities were described in the unit of 30 min, which roughly represented one class session.

In half an hour, the IdeaKeeper students spent 2 min skimming four sites and 15 min reading one site, while the Google students spent 4 min skimming eight sites and 9 min reading 2.5 sites. Clearly, the Google students’ online reading was much more cursory than their counterparts. Table 2 describes the number of sites that the students skimmed and read and the length of time on skimming and reading in half an hour.

Analysis on how the students spent time skimming and reading revealed that the differences between the two groups mainly lay on the time spent on reading. Both groups spent similar time skimming websites, each about 30 s per site. However, the IdeaKeeper students on average spent about 16.5 min reading a site, while the Google students spent about 3.6 min. Table 2 describes the time on skimming and reading per site for each pair, and Fig 2 presents a summary for each group.

In sum, the students in both groups spent similar amounts of time deciding whether a site was worth reading. Yet, after they chose to read a site, the IdeaKeeper students spent much longer time reading the site than the Google students. In other words, the IdeaKeeper-supported online reading was more deliberate than the unguided online reading.

Fragmented versus thorough reading

Consistent with the cursory reading pattern discussed earlier, the Google students also read in a fragmented
manner—reading only some disconnected words or sentences without reading a reasonable amount of text in order to develop a coherent understanding. It is important to distinguish fragmented reading from selective reading. Selective reading is a characteristic of skilled reading, in which readers adjust their reading speed according to the perceived importance of text to their goals, slow down and pay careful attention when encountering important text (Pressley & Afflerbach 1995; Brozo & Simpson 2002). In fragmented reading, however, readers read a few discrete words or sentences out of their temporary interest, rather than driven by the reading purposes. The reading pattern demonstrated by the Google students was fragmented, rather than selective reading.

The Google students rarely finished reading the majority of the contents in a website. Some students did not even read a whole paragraph. Typically, they scrolled up and down a web page, making few comments about the pictures or animations that drew their attention, and picking up some words or sentences. The IdeaKeeper students read more thoroughly because they needed to answer the prompting questions, which encouraged them to read a significant portion of text in a site. Table 3 describes the level of fragmented reading for each pair. Pair 1 and Pair 3 read most thoroughly, while Pair 7 and Pair 8 read in a highly fragmented manner. The other pairs were in between.

To illustrate the patterns of fragmented and thorough reading, two examples are provided. The example for fragmented reading was a website called Temperate Oceans that Pair 7 read on day 7. This site was chosen because some of its content was directly relevant to Pair 7’s driving question, which asked about why the ocean is salty. The heading of the second last paragraph in this web page was why is the ocean salty, which worded

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**Table 2.** Average time on skimming and reading in 30 min and per site.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pair</th>
<th>Number of sites being skimmed in 30 min</th>
<th>Time on skimming in 30 min</th>
<th>Number of sites being read in 30 min</th>
<th>Time on reading in 30 min</th>
<th>Time on skimming per site (min)</th>
<th>Time on reading per site (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IdeaKeeper</td>
<td>Pair 1</td>
<td>1.0</td>
<td>0.6</td>
<td>1.0</td>
<td>20.1</td>
<td>0.7</td>
<td>21.5</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>8.3</td>
<td>2.5</td>
<td>1.1</td>
<td>9.3</td>
<td>0.3</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>3.8</td>
<td>2.6</td>
<td>1.5</td>
<td>16.4</td>
<td>0.7</td>
<td>10.8</td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>2.0</td>
<td>1.4</td>
<td>0.6</td>
<td>14.5</td>
<td>0.7</td>
<td>25.1</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>4.0</td>
<td>1.8</td>
<td>1.1</td>
<td>14.7</td>
<td>0.6</td>
<td>16.5</td>
</tr>
<tr>
<td>Google</td>
<td>Pair 5</td>
<td>5.0</td>
<td>2.0</td>
<td>3.1</td>
<td>11.7</td>
<td>0.4</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Pair 6</td>
<td>5.1</td>
<td>3.4</td>
<td>2.8</td>
<td>13.6</td>
<td>0.7</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>Pair 7</td>
<td>8.2</td>
<td>4.2</td>
<td>2.1</td>
<td>6.4</td>
<td>0.5</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Pair 8</td>
<td>12.9</td>
<td>6.4</td>
<td>2.2</td>
<td>6.6</td>
<td>0.5</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>7.9</td>
<td>4.0</td>
<td>2.5</td>
<td>9.4</td>
<td>0.5</td>
<td>3.6</td>
</tr>
</tbody>
</table>

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![Fig 2 Average time on skimming and reading per site.](image)
exactly the same as their driving question. The text in
the website was presented in a question-and-answer
format. Although there were not many visuals in this
site, it was not hard for sixth-grade students to read.

When Kale and Irvin opened the website, they first
read the heading, why is the ocean blue, which was
immediately followed by an off-topic comment by Irvin
(‘Why is anything blue? Why do we have colors? Why
are we alive? I’m colorblind’). His partner, Kale ques-
tioned him, ‘I wonder what’s so funny. You keep saying
that.’ They then continued their off-task conversation
and scrolled up and down the website without reading
the text. When they scrolled up the web page to the top
again, they read the first sentence of the first paragraph,
why is the ocean blue? No one knows for sure. They
then continued to scroll down the web page again, at
the same time, arguing about who should control the
mouse. Although the section why is the ocean salty was
clearly relevant to their driving question, they did not
pause to read the content. Instead, they kept scrolling up
and down the web page several times. Finally, they
scrolled to the bottom of the website, silently skimmed
some text, and read the last sentence, about one cup per
gallon, commenting ‘that is an interesting fact,’ which
was the only comment they made about the content
during the entire reading of the site. Then they scrolled
up the web page again.

In sum, Pair 7 read only three fragmented sentences
in the website. The pattern of fast scrolling and frag-
mented reading, mixed with frequent and lengthy off-
task conversation, was typical for Pair 7.

In contrast, the IdeaKeeper students demonstrated
more thorough reading than the Google students. One
eexample was a website read by Pair 1 on day 3, why is
acid rain harmful. They started with answering the
skimming tab questions in the IdeaKeeper notepad.
After that, they went to the reading tab. Their reading of
the site started when they were answering the third
question, what information helps me answer my ques-
tions, as shown in the following excerpt.

Abby: What information helps me answer my question?
Ok. Let’s read.
[Reading text] Air pollution like sulfur dioxide and nitro-
gen oxides can cause respiratory diseases.
Abby: Ok, do we already have that on the other one
[referring to a site they read before]?
Dane: I think we can say it can cause respiratory,
Abby: Yeah. So, can cause respiratory diseases?
[Taking notes in the IdeaKeeper notepad by typing] can
cause respiratory diseases.
[Reading text] Respiratory diseases like asthma or
chronic bronchitis make it hard for people to breathe. The
pollution that causes acid rain can also create tiny par-
ticles. Ok, so,
[Taking notes] pollution in acid rain can have little par-
ticles. Ok.

The pattern of text reading and note taking continued
until Pair 1 finished reading all of the text in the website.
They then answered the remaining questions in the
notepad. During their reading of the site, Pair 1 showed
18 occurrences of text reading and 13 occurrences of
note taking. They also discussed what they read to make
sense of the text.

Because Pair 1 read almost all the text in the web
page, it is important to note that their reading was based
on their evaluation for the site, rather than unselective,
‘all-text-is-important’ reading. First, before they read
the text, Pair 1 skimmed the site and made comments:
‘this is a very good website. There is a lot of stuff.’ After
they looked further at the links in the site, they found

<table>
<thead>
<tr>
<th>Group</th>
<th>Pair</th>
<th>Total number of sites being read</th>
<th>Thoroughness</th>
<th>Purposefulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>IdeaKeeper</td>
<td>Pair 1</td>
<td>7</td>
<td>Thorough</td>
<td>Purposeful</td>
</tr>
<tr>
<td></td>
<td>Pair 2</td>
<td>12</td>
<td>Somewhat fragmented</td>
<td>Purposeful</td>
</tr>
<tr>
<td></td>
<td>Pair 3</td>
<td>5</td>
<td>Thorough</td>
<td>Purposeful</td>
</tr>
<tr>
<td></td>
<td>Pair 4</td>
<td>11</td>
<td>Somewhat fragmented</td>
<td>Purposeful</td>
</tr>
<tr>
<td>Google</td>
<td>Pair 5</td>
<td>34</td>
<td>Somewhat fragmented</td>
<td>Somewhat opportunistic</td>
</tr>
<tr>
<td></td>
<td>Pair 6</td>
<td>23</td>
<td>Somewhat fragmented</td>
<td>Somewhat opportunistic</td>
</tr>
<tr>
<td></td>
<td>Pair 7</td>
<td>23</td>
<td>Fragmented</td>
<td>Opportunistic</td>
</tr>
<tr>
<td></td>
<td>Pair 8</td>
<td>22</td>
<td>Fragmented</td>
<td>Opportunistic</td>
</tr>
</tbody>
</table>
that the site was exactly what they needed. Abby commented, ‘One of our questions is what can we do [about acid rain] and what is being done, so we can do that [link], after we look at this one.’ ‘What can we do’ and ‘what is being done’ were two subheadings in the site. After more reading of the site, Abby commented again, ‘This is definitely related to our question.’ Therefore, unlike Pair 7 who only read some fragmented words in a site relevant to their question, Pair 1 read much more thoroughly the site that they considered useful.

**Opportunist versus purposeful reading**

Data analysis showed that the Google students’ online reading was not only fragmented, but also opportunistic. The students’ attention often drifted among different elements of a website driven by temporary interests. What drew their attention was random, opportunistic, and hard to anticipate. A clear, logical connection between two consecutive focal points of students’ attention was often lacking. The focal point of students’ attention was inferred from their computer screen mouse movements and their verbal conversations. The students often moved the mouse to a certain portion of a site that drew their attention, in addition to verbal utterances with their partner. The mouse movements in combination with verbal utterances clearly signalled what the students were focusing on at a certain point.

Pair 5’s reading of a website called *Zeroing in on ocean dead zones* illustrated the pattern of opportunistic reading. Pair 5 spent about 17 min reading and taking notes from this site. When they opened the web page, their attention was first drawn to an image on the right side. Then their focus shifted to the first paragraph, without explicit explanation about the change of focus. After reading two paragraphs, their attention moved to the left side, where a quote was highlighted in bold fonts. Next, they jumped back to read the text in the third paragraph and started taking notes.

After note taking, their attention was drawn to an image on the top left corner, and they clicked the icon to open a new pop-up window. Soon they closed the window and returned to the previous web page. Then they had an off-task talk with their neighbour about whether water burns. Next, they took notes for the fourth paragraph and read the first sentence in the sixth paragraph. Their focus was then moved to the related stories and links on the right side, followed by an off-task talk with their neighbour again. Finally, they came back to the sixth paragraph to read and take notes before the teacher stopped the class. Overall, their attention shifted about 10 times among different elements of this website. Figure 3 illustrated Pair 5’s attention flow on this site.

On the other hand, the IdeaKeeper students’ reading was guided by the prompting questions in the notepad, which made their reading more purposeful. Typically, when the IdeaKeeper students opened a site, they first skimmed the site to decide if it was worth reading. If so, they would answer the evaluation questions in the skimming tab, and then move to the reading tab. Their reading of the site usually occurred when they tried to answer the prompting questions in the reading tab. Particularly, question 3 in the reading tab, *what information helps me answer my questions*, often triggered reading. Pair 4’s reading of a site called *Hard water* was a good example to illustrate this pattern.

After opening the web page, Pair 4 started with reading the first and second paragraphs in the site. During their reading, Bona evaluated the relevance of the information and made comments such as ‘That is not what we are looking for,’ or ‘That is one of our questions.’ Then they wrote notes for the third prompt in the reading tab. After note-taking, Bona commented on the information and returned to the text. She was excited to find some information useful for their question, as shown in the following remarks.

Bona: Ok, that definitely helps us. Well, that is one of our sub questions, and, [scrolled down a little] let’s see, health effects. This really helps us too. [Read text] hard water is not a health hazard. [Commented] Ok! That really helps.

Next, they continued to read the text, and decided to take notes of the information they read. However, they were not sure how much information they needed to take notes of, so they skimmed some text and decided they did not need those. They continued to read the paragraph that they considered useful and tried to make sense of the meaning of the text. They then took notes for prompt 3, ‘Hard water is not necessary bad for you,’ and commented, ‘Ok. That is really important.’ Next, they skimmed the remaining text and read the last paragraph.

Bona and Dylan were purposeful about where they paid their attention. Their focus was driven by their research question and guided by the prompts. They assessed the usefulness of the information and made
Zooring In On Ocean Dead Zones

NEWPORT, Ore., August 12, 2004

(AP) His hand on a toggle switch and his eyes on a computer screen, Oregon State University graduate student Anthony Krunich uses an array of scientific instruments to probe the vibrancy of the water in the Pacific.

He is searching for the absence of life.

Standing next to him in the cramped cabin of the research vessel Elakka, new doctoral researcher Francis Chan said, "CBS sampled 270 samples, measuring oxygen and the microscopic plants that are the foundation of the food chain.

Both are hunting for very low levels of oxygen, a sign of what scientists call the Dead Zone. In search of the appearance of such a zone that cannot sustain life may be a sign of a fundamental change in the Pacific.

"We don't fully understand what the cause of that is. We have some preliminary data that it is related to some fundamental changes in circulation and the source of water for the Oregon Continental Shelf."

"This is definitely a cat-and-mouse game," said Chan. "It really takes us almost daily trips to really pinpoint the data."

Two years ago when local fishermen started hauling up pots filled with dead crabs, scientists fanned out to test for a layer of sub-Arctic water with very low levels of oxygen and high levels of nitrogen that had welled up from the ocean's depths and settled in the summer in the Continental Shelf off central Oregon.

The Dead Zone dissipated that fall, and based on 40 years of ocean monitoring and local fishing lore, many thought they would never see it again. This summer, the Dead Zone came back.

"What I think we are seeing is a tipping of the balance of the ecosystem," said Jack Barth, a professor of oceanography at Oregon State University. "We don't fully understand what the cause of that is. We have some preliminary data that it is related to some fundamental changes in circulation and the source of water for the Oregon Continental Shelf."

There are more than 30 man-caused dead zones — scientists call them hypoxic or low-oxygen events — around the world in enclosed waters, including Hood Canal in Puget Sound, the Mississippi River delta and Chesapeake Bay.

There, excess fertilizer from farm fields washing down rivers fuels a surge in microscopic plants called phytoplankton. When they die, bacteria decomposition uses up the oxygen, turning the areas into dead zones with virtually no life.

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conscious decisions about what should be skipped, read, or recorded.

Bona: Ok. [Scrolled down the text] Well, we don’t need anything about testing, and, this chart is just hard to read. [Continued to scroll down] well, maybe we can add, oh, wait, it says, [Read text] summary, hard water is not a health hazard, but dealing with hard water in the home can be a nuisance . . .

After reading the site, Pair 4 answered the remaining prompts in the reading tab with reference to the site. They then went to the summary tab to summarize what they had learned. Overall, among a total of 19 turns of focus shifting in their reading of the site, eight were related to the text in the site and 11 related to the prompting questions in the IdeaKeeper notepad. Figure 4 illustrated Pair 4’s attention flow on this site.

In the previous example, Pair 1’s reading of the site why is acid rain harmful was also guided by the prompting questions in the IdeaKeeper notepad. In addition, Pair 1’s reading was also purposeful, rather than opportunistic. The comments they made during their reading clearly suggested their purposefulness, such as, ‘That is very helpful,’ ‘That is not very important,’ ‘Ok, that is not really what we want to know,’ ‘This is good,’ ‘What does that have to do with anything?’ ‘Let’s see if this is related to our question. See if it says anything about acid rain,’ ‘We already know that,’ and ‘What does that have to do with acid rain?’ Such comments were rarely made by the Google students.

In addition, the Google students showed a preference at pictures over text. Often, a picture immediately drew their attention when they encountered a website, regardless of its relevance to their question. Also, pictures were often the focus of their conversations in the site. Sometimes they complained a site being ‘boring’ because of not having pictures. In contrast, the IdeaKeeper students were more persistent in reading textual sites because their reading was structured by the IdeaKeeper notepad. They rarely complained about a site for having merely text. Specifically, among the 35 websites that the IdeaKeeper students read, 17 sites did not have pictures, 13 sites had pictures that the students found helpful, and five had distractive pictures, according to the students’ evaluation in answering the questions in the skimming tab. In sum, unlike the Google students, the IdeaKeeper students seemed to be conscious about the usefulness of pictures.

Discussion

This study analysed the differences between guided and unguided online reading performed by sixth graders in a science inquiry project. In guided online reading, the students were presented with an explicit skim–read–summarize structure, responded to a series of prompts, and connected to learning purposes, while unguided online reading lacked such support as in typical situations when students use online resources. Data analysis showed that unguided online reading by the sixth graders tended to be cursory, fragmented, and opportunistic, while guided online reading was more deliberate, thorough, and purposeful.

The three key strategies that were implemented in the design of the IdeaKeeper notepad appeared to be effective in changing students’ natural online reading processes towards more desirable ones. First, the skim–read–summarize task structure disrupted the tendency of hasty reading on the Web by engaging students in evaluating, reading, note taking, and summarizing activities. Without such a structure, the Google students rarely spontaneously evaluated a site or summarized their learning. It was also rare for them to identify and take notes for main ideas and supportive evidence from the web pages they read. Second, the prompts helped students read more thoroughly. To answer the prompting questions in the IdeaKeeper notepad, students had to read the content and articulate their learning. Third, connecting students’ reading to their learning goals led to more purposeful reading. Students were less likely to be distracted by irrelevant pictures and animations when they were reminded of their goals.

This study has important implications for using Internet resources in classrooms. Prior research has mainly reported problems in students’ online reading of scientific resources (Wallace et al. 2000; Kuiper et al. 2009), while few studies have examined the classroom use of technology-enhanced tools that aimed to address the problems. Consistent with prior research, this study also found that unguided online reading was problematic. Moreover, this study illustrated the problematic online reading systematically in terms of how long, how much, and in what ways that middle school students read online scientific resources through in-depth analysis of screen videos that were collected in an extended period of time.

Given the increasingly common use of online resources in classrooms, it is alarming to note that deep
learning on the Web is hard and students need substantial guidance to develop meaningful learning from online resources. Unfortunately, teachers are often unaware of students’ needs for guidance and structure in reading online resources and tend to focus on technical skills in instruction when integrating Internet resources in their teaching (Ruthven et al. 2005; Kuiper et al. 2009). This study suggests that teachers need to become aware of the typical problems that middle school students have with reading online resources.

More importantly, this study provides evidence for effective supporting strategies to help students move beyond cursory, fragmented, and opportunistic online reading. These strategies can be adapted by classroom teachers or educational technology designers to develop effective online learning environments. Future research
should examine how students develop content understanding in structured or regular online reading. In addition, it is important to explore how the strategies can be adapted to support elementary or high school students.

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References


