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Comparing the Quality of Third, Fourth, and Fifth Graders' Social Interactions and Cognitive Strategy Use During Structured Online Inquiry

JULIE COIRO, UNIVERSITY OF RHODE ISLAND, DIANE CARVER SEKERES, UNIVERSITY OF ALABAMA, JILL CASTEK, PORTLAND STATE UNIVERSITY, AND LIZABETH GUZNICZAK, OAKLAND UNIVERSITY

ABSTRACT

This study examined the social and cognitive interaction patterns of third, fourth, and fifth graders as they collaboratively read on the Internet and responded to an inquiry prompt. Data analysis revealed patterns of cognitive strategy use that intersected with social forms and functions of dialogue. Dyads that exhibited higher levels of cognitive strategy use and mutually collaborative social interactions were better able to accomplish the inquiry task. Pairs who read with little or no meaningful discussion were less successful. These contrasting cases show the range of interaction patterns that may occur during co-constructive inquiry-based online reading. Findings can inform the design of instructional scaffolds to foster productive dialogue and strategic reading in online spaces.

Internet technologies are rapidly changing the landscape of reading and writing (Coiro, Knobel, Lankshear, & Leu, 2008; Dalton & Proctor, 2008), as well as the ways in which readers interact with text and other individuals (Selfe & Hawisher, 2004). Skilled online readers rely not only on new reading skills and strategies (Leu, Kinzer, Coiro, Castek, & Henry, 2013), but they also socially construct understandings of diverse online texts in complex ways (Coiro, Castek, & Guzniczak, 2011; Cope & Kalantzis, 2000; Foster, 2009; Kiili, Laurinen, Marttunen, & Leu, 2012).

In the context of classroom learning, recent work highlights an important shift in emphasis from experiences that foster learner recall and information transmission to those that develop personal understanding and co-construction of new knowledge (Assessment and Teaching of 21st-Century Skills [ATC21S], 2008; IRA & NCTE, 2010; Wells, 2007). Recent *Common Core State Standards* (2010) reflect this reality. They call for learners to be skilled at close reading and meaningful discussion while engaging with multiple informational texts and participating in productive collaborations involving inquiry-based print and digital research practices. In order to consider how best to design co-constructive inquiry-based reading experiences, it is important to understand more clearly how such interactions operate to promote learning.

Previous research provides a useful foundation for understanding the skills, strategies, dispositions, and practices of good readers in print and online contexts. We know that good readers actively apply a set of metacognitive reading processes (Palincsar & Brown, 1984; Pressley, 2000), and have the skills to engage in quality classroom discussions (Mercer, 1995; Soter et al., 2008). Moreover, good readers tend to thrive when engaged in inquiry-based opportunities where they can guide the direction of their reading and research (Guthrie et al., 2004). Within these types of learning activities, they are able to collaboratively support each other's use of technology to make sense of ideas (Castek, 2008; Dwyer, 2010). These practices can help inform instructional decision making about online reading experiences designed to address rigorous new standards.

Nevertheless, studies of productive online reading during open-ended Internet inquiry tend to focus more on adolescents and young adults (e.g., Coiro & Dobler, 2007; Coiro et al., 2011; Cho, 2011; Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012; Zhang & Duke, 2008) than on younger learners. Although research involving younger students has begun to emerge (Castek, 2008; Dwyer, 2010; Kingsley, 2011; Steffens, 2012), most of this work explores online reading and learning through cognitive lenses as opposed to considering the role that social collaboration and partner dialogue may play in fostering productive online reading research and comprehension practices. This study seeks to build on work emerging in this area while explicitly calling more attention to the overlapping cognitive and social aspects of online reading comprehension.

PURPOSE

This study examined patterns of social and cognitive interaction emerging from video and interaction protocol data collected from six dyads in Grades 3–5 as they collaboratively read on the Internet and responded to an inquiry prompt. More specifically, we sought to better understand which patterns of cognitive strategy use and social interaction appear to be more or less productive during online inquiry. The findings can add to emerging work focused on elementary-age learners to help reading researchers and classroom teachers more explicitly characterize both cognitive and social aspects of productive interactions between students as they work with partners during online inquiry. Once we better understand the nuances of productive collaboration during online inquiry, we can turn our attention to thinking about how to design instruction and digital scaffolds that may foster these practices as part of regular classroom reading experiences in elementary school settings.

THEORETICAL PERSPECTIVES

We approached this work through three theoretical lenses that conceptualize reading in terms of overlapping dimensions of individual cognition and social interaction. First, our conceptions of

reading comprehension were grounded in Vygotsky's (1962) sociocultural theory that argues learning is fundamentally a social activity where personal knowledge is co-constructed in a social space. This perspective asserts that knowledge does not reside solely in one's mind but is distributed across individuals whose joint interactions and negotiations determine decisions and solve problems (Bruner, 1986). Accordingly, expert readers apply a range of strategic social and cognitive processes as they work together to navigate and negotiate meaning across multiple digital texts.

Secondly, this study combined elements of a new literacies perspective of online reading comprehension with key tenets of social constructivism (Coiro, 2011). We define online reading comprehension as a self-directed, web-based inquiry process involving skills, strategies, dispositions, and practices for locating, evaluating, synthesizing, and communicating information on the Internet (Leu et al., 2013). In addition, we believe that meaningful learning in online environments emerges by embedding cognitive processes into specific forms of goal-directed interaction and dialogue (see Kozulin, 1998). From this perspective, the process of cognitive development lies outside the individual, in the tools they use (e.g., language) and their interpersonal relations with others. It was through these overlapping lenses of new literacies and social constructivism that we sought to more closely examine the use of cognitive reading strategies and social interactions between partners within a single analytic framework to better understand how talk is used to think together during online inquiry.

Notably, while we recognize that cognitive and social processes do not exist as separate entities, we initially sought to clarify our thinking about each construct separately and then explored them simultaneously as mutually reinforcing dimensions of the online comprehension process. We defined *cognitive strategies* as the set of active meaning-making strategies used to construct an understanding of complex text. *Social interactions* were the forms and functions of talk that occurred as pairs of students read, interpreted, and organized information in response to a structured online inquiry prompt.

The third lens was Granott's (1993) Interaction Model, which describes patterns of interaction that occur in the co-construction of knowledge. This model acknowledges the importance of social interaction for the development of an individual's cognition. Granott characterized collaborative interactions across two dimensions: levels of knowledge and expertise (cognitive) and degrees of collaboration (social). We applied our constructs to this model and used it to inform our comparison across dyads with respect to level of cognitive strategy use and degree of collaboration as students engaged with each other and the texts to complete a researcher-designed structured online inquiry task.

PREVIOUS RESEARCH

A large body of work suggests that secondary students struggle with online inquiry tasks, especially with respect to their proficiency with online research and reading comprehension skills (e.g., Eagleton, 2003; Henry, 2006; Kuiper, Volman, & Terwel, 2005; Walraven, Brand-Gruwel, & Boshuizen, 2009). However, some studies have found that working in pairs may lessen the challenges of reading on the Internet and may foster more efficient and productive comprehension of online informational texts—even among readers who are skilled at comprehending online texts (see Castek, Coiro, Guzniczak, & Bradshaw, 2012; Kiili et al., 2012). These studies suggest that productive online collaboration between pairs of older students appears to involve overlapping cognitive and social literacy practices—such as reading actively to determine important ideas—and to integrate these practices within and across texts while balancing a range of functional exchanges (give, request, monitor, and react) where speakers question, reinforce, and extend each other's ideas. Thus, it makes sense to frame the present study of online reading among younger students as a collaborative cognitive and social practice of self-directed inquiry during which dialogue plays an important role in shaping meaning.

A second area of research suggests that certain scaffolds associated with reading tasks, text types, and social contexts may facilitate active meaning making and engaged reading (RAND Reading Study Group, 2002). For example, prereading opportunities that help readers activate and build background knowledge can prompt higher levels of comprehension and learning during and after reading (Alexander & Jetton, 2000). Similarly, access to multimodal texts can broaden and enhance meaning-making opportunities (Kress & Van Leeuwen, 2001; Lemke, 1998). Finally, working with a partner on a meaningful reading task framed as personal inquiry has been shown to facilitate comprehension and reading motivation in offline and online reading contexts (Dillenbourg & Schneider, 1995; Foster, 2009; Guthrie, Wigfield, & Klauda, 2012; Minstrell & Van Zee, 2000).

These findings suggest that younger children in particular may respond positively to an online reading task that includes opportunities to activate and build prior knowledge, work with a partner, and direct their own reading paths through networked multimodal texts in the context of an inquiry-based, authentic information problem. Yet, to date, little is known about how young children actually engage with these types of digital and social affordances as part of online inquiry. To that end, our research was framed around one main question: How do pairs of third, fourth, and fifth graders cognitively and socially engage with each other during structured online inquiry? As we examined this question, we considered the extent to which students' cognitive and social interactions reflected active meaning making and collaborative dialogue as part of online inquiry.

METHODS

Participants

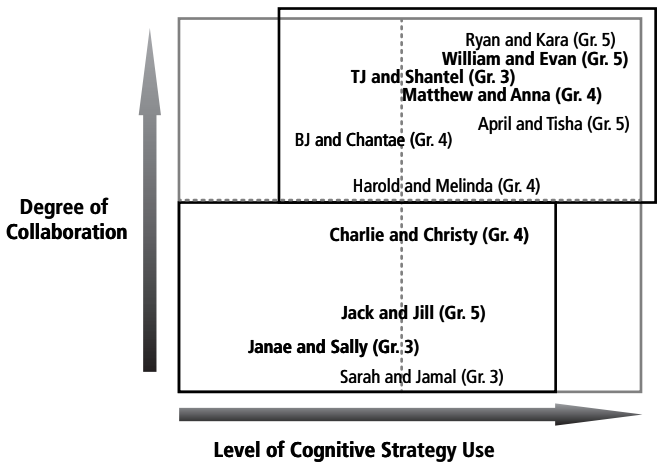
An initial sample of 24 participants was purposefully selected (Merriam, 2009) in equal numbers from two third-grade, two fourth-grade, and two fifth-grade classes. All participants attended the same magnet school in a midsized city in the southeastern

United States. Criteria for students to be accepted to this school included performance on or above grade level on a criterion-referenced reading and math test. Of the 316 students in Grades PK–5, 41% were eligible for free or reduced lunch; 53% of the students were African American, 39% White, 6% Hispanic, and 2% Asian. The school's technology integration specialist helped to recruit teachers willing to have their students participate in the study. He asked teachers to select strong readers who were interested in participating, reliable in novel situations, and tended to work well with others. The teachers paired students into dyads randomly as they left the classroom to walk to the computer lab where the inquiry took place. The pairs also varied by gender, race, and prior topical knowledge, although without design (see Table 1).

For this focused contrastive case study (Yin, 2009), we sought to highlight talk that represented comparative examples of more and less productive cognitive strategy use and social interactions at each grade level. Consequently, an illustrative subsample of six dyads was selected from the larger sample of 11 cases. (After losing data from one dyad, 11 dyads with full videos remained.) Purposive sampling was employed to select six dyads (two at each grade level) that fell into one of two contrasting squared regions of a two-dimensional continuum of interactions that typically occur in the coconstruction of knowledge (adapted from Granott's [1993] Interaction Model), as shown in Figure 1. The upper region of the figure includes dyads that displayed interactions at the higher end of both social and cognitive dimensions while engaged in online inquiry, and the lower region includes dyads with observed interactions at the lower end of both dimensions.

Names of the six selected dyads are bolded in Figure 1 to signify their inclusion in this focus study (all names are pseudonyms). In Grade 3, we selected Janae and Sally on the lower end and TJ and Shantel at the higher end to compare and contrast their interactions on cognitive and social dimensions. In Grade 4, we selected Charlie and Christy, who fell in the middle of the continuum but still much lower on both dimensions than the other selected dyad, Matthew and Anna. In Grade 5, we selected Jack and Jill on the lower end to compare with William and Evan on the higher end of both dimensions. Data from these six purposively selected contrastive cases were used to provide an initial window into the range of levels of cognitive and social interactions upper elementary teachers might encounter when engaging students with online inquiry in their classrooms.

Figure 1. Level of Cognitive Strategy Use



Eleven original dyads situated along dimensions of higher and lower levels of cognitive strategy use and degrees of social collaboration observed during online inquiry using an adapted version of Granott's (1993) Interaction Model. The names of six dyads (pseudonyms) selected for this focus study are highlighted in bold.

Table 1. Participant Characteristics by Dyad

Dyad	Grade Level	Race and Gender	Prior Knowledge (Pretest of 10 multiple-choice questions)			
			Terms (4 total)	Materials (3 total)	Effects (3 total)	Total (10 total)
Janae & Sally	3	BF/WF	3	1	2	6
TJ & Shantel	3	WM/BF	4	3	2	9
Sarah & Jamal	3	WF/BM	3	1	2	6
BJ & Chantae	4	BF/BF	2	1	2	5
Charlie & Christy	4	WM/WF	3	3	2	8
Harold & Melinda	4	BM/WF	2	2	2	6
Matthew & Anna	4	WM/WF	3	2	2	7
Jack & Jill	5	WM/WF	3	3	2	8
Ryan & Kara	5	WM/BF	4	3	2	9
Tisha & April	5	BF/WF	4	2	2	8
William & Evan	5	WM/BM	3	2	2	7

Note. Race and gender is denoted as follows: BF = Black Female; WF = White Female; BM = Black Male; WM = White Male. Prior knowledge items were divided into three sections: Terms = Ecological terms; Materials = Materials used in toys; Effects = Ecological effects of manufacturing. Scores were calculated by totaling the correct items in each section between each pair.

Data Sources

The researchers designed the structured online inquiry task as an authentic problem that dovetailed with students' units of environmental study, which gave the task familiarity and value. Different from open inquiry tasks (where students define the question and make all the decisions with no guidance from a teacher), structured inquiry tasks enable students to make some choices, but these choices are dependent upon guidelines and structure given by the teacher (see Alberta Learning, 2004).

For our structured inquiry task, directions (see Appendix A) explained that a popular toy store was opening a Green Toys Shop in a nearby mall, and the managers were asking students to recommend four eco-friendly toys for the shop. The four-step directions asked students to visit an overview page, conduct an Internet search for toys, choose the most useful information, and give a rationale for four toys in an interview that followed the 30 to 40 minutes spent online completing the task. The overview page (see Appendix A) was constructed to provide students additional background knowledge about the topic and a short bulleted list of 12 key ideas organized under three major headings. Seven embedded hyperlinks were included to connect readers to additional information about environmentally safe products and practices: for example, common pollutants used in toys and decomposition rates of common items. Another resource was a short video about how eco-friendly toys are made. These websites were selected because they pointed readers to relevant information and/or multimodal images and video that we believed would help elementary-age children activate and build background knowledge to inform their subsequent search for eco-friendly toys. Students were not required to follow the embedded hyperlinks on the overview page; rather, they were told to read whatever they thought might be useful for the task.

For the search portion of the task, a Google Custom Search Engine (see www.google.com/cse/) directed students to websites preselected by the researchers. This ensured that students would not encounter inappropriate websites, a concern of teachers at the school. These preselected resources included approximately 70 web pages across 25 unique websites that showcased environmentally friendly toys, materials used in their manufacture or packaging, or pollutants sometimes used in producing goods. Although constrained for child safety reasons, this set of online resources was designed to reflect an authentic online reading experience. For example, only a few of the sites included in the overview page or the Custom Search Engine were written specifically for children, so the reading was often challenging, with unfamiliar vocabulary and long, complex sentences. In addition, this collection of sites included several less relevant websites that served as potential distracter sites as children scanned the search results for useful information.

Data Collection

Dyads completed the online inquiry task over two weeks. Each dyad met with a researcher in the school's computer lab; often, classes were also present for regular instruction while the dyads performed the task. Using a standardized protocol to give directions for the task, the researcher asked students to read aloud from the home page that explained the assignment. Student pairs were instructed to talk together as they performed the given task. This natural dialogue reflected interaction protocols (Miyake, 1986) that provided researchers access to the collaborative meaning making of each dyad. Camtasia screen capture software (www.camtasia.com) was used to simultaneously capture into one video file all the students' on-screen reading actions, face-to-face discussions, and verbal/nonverbal interactions with the text and with each other. After students completed the task, the researcher interviewed them, using a standardized interview protocol, about the toys they selected and their experience performing the task. The individual sessions ranged from 30 to 45 minutes, including the researcher's directions, the students' research, and the interview in which the students explained their choices.

Data Analysis

Our goal was to provide an initial window into the range of interactions teachers might encounter when engaging students with online inquiry in their classrooms. Consequently, a contrastive case study approach (Yin, 2009) was used to analyze video data in three phases to explore similarities and differences between each pair of students. In Phase 1, each researcher viewed the videos independently to get a general sense (Tesch, 1990) of how each pair was interacting with each other both cognitively and socially. The research team then exchanged initial impressions across all the dyads before moving to Phase 2.

In Phase 2, deductive coding procedures (Yin, 2009) were used to simultaneously apply two previously developed coding schemes while analyzing each dyad's dialogic interactions as they completed the structured inquiry task. Cognitive strategy use (see Appendix B) was coded using a set of constructively responsive online reading processes observed in previous work (Coiro, Guzniczak, & Castek, 2010; Castek et al., 2012), such as planning a search, connecting key ideas within the text, making inferences, or changing the reading pathway to locate more relevant text. Social interactions (see Appendix C) were coded using categories that characterized the social function of each dialogic move, such as requesting clarification, giving an example, or reacting to a previous contribution (Coiro et al., 2011). This combination of coding structures revealed insights into how patterns of cognitive strategy use intersected with social forms and functions of dialogue to represent the richness and complexity of collaborative online reading processes. Once we developed a complete understanding of the interaction patterns within each case, we were able to revisit the data across all the cases and detect possible matching patterns.

In Phase 3, to compare and analyze the interaction patterns across these six dyads, we ranked the students' interactions on two axes adapted from Granott's (1993) Interaction Model: their level of cognitive engagement with the task (based on strategy use) and the quality of their collaboration (based on their social interactions). We then used inductive reasoning and discourse analysis

techniques (Wood & Kroger, 2000) to categorize as "more productive" those dyads whose talk had a higher degree of cognitive engagement and social collaboration, and "less productive" those dyads whose talk exhibited a lower degree of cognitive engagement and/or social collaboration. To a limited extent, we also considered the qualities of each dyad's subsequent search for relevant texts (and toys) and the quality of their oral summary of their choices and reasoning. These considerations allowed us to make preliminary judgments about each dyad's use of the overview page in relation to their final product, which was comprised of their four toy choices and their reasoning for each. These rankings and eventual groupings enabled us to highlight instances where quality collaboration and high cognitive engagement led to strategic inquiry processes and co-construction of new knowledge. Similarly, data from other dyads illuminated the types of social and cognitive interactions that might justify support in order to redirect partners toward more productive interactions with each other and with the texts they encounter during online inquiry.

FINDINGS

Our findings are presented in two sections to parallel the two levels of analysis. First, we compare and contrast the cognitive and social interactions observed within each dyad in our subsample as they read within the overview page and associated hyperlinks to learn more about eco-friendly toys. Dyads are sequenced by grade level, and comparisons are made between the two contrasting dyads at that grade level to better understand how the complexity of online collaborative reading can play out quite differently among dyads within each grade level. Second, we characterize the patterns that existed across grade levels for those dyads whose inquiry processes were more productive and those whose processes were less productive.

Contrastive Case Studies Within Grade Levels

Grade 3: TJ and Shantel. Overall, TJ and Shantel were cognitively strategic in their reading. Approximately 19% of their strategy use was spent making connections between the online text and their prior experiences and knowledge. They made inferences about the meaning of the text 21% of the time. Using these two cognitive strategies together (totaling 40% of their interactions), TJ and Shantel skillfully interpreted what they read in light of their prior knowledge and in relation to the task. They read conscientiously and took time to discuss the content they encountered, connecting their reading to both home and school. For example, after reading that a good toy choice is one that is biodegradable and therefore will not damage the earth, Shantel noted that Sun Chips bags were an example, to which TJ responded, *"Just like banana peels!"* Shantel then jumped to *". . . compost!"* Even though they eventually agreed that compost is stinky, they planned to compost at home in the future *"because it helps out the environment."* On average, this actively engaged pair followed each chunk of reading aloud with more than four times as much discussion.

In addition, the dyad functioned well socially, exchanging information, interpretations, examples, and opinions through courteous, extended conversation. They asked for clarification and sought suggestions from each other about how to find more information. Shantel was slightly more talkative, with 54% of the turns, but both partners contributed substantively. TJ was more likely to offer suggestions, while Shantel was more likely to probe for understanding. The following example illustrates their collaborative attempts to co-construct an understanding of the term "rubberwood."

Shantel:	*Rubber wood? I'm not sure . . . I don't think it's really wood that you carve on.*
TJ:	*I don't think it's very . . . it's very strong wood. I think it's like this rubbery kind of wood.*
Shantel:	*I don't think it's exactly made of rubber.*
TJ:	*But it's kind of like not that strong . . .*
Shantel:	*Maybe it's kind of stretchy as you might say . . . stretchy?*
TJ:	*Yeah.*
Shantel:	*But . . . stretchy game pieces?*
TJ:	*Stretchy game pieces.*
Shantel:	*And stretchy wooden blocks. . . . Stretchy dolls. . . .Well, that makes sense.*

Eventually, this dyad's toy choices stemmed less from what they read and more from their own ideas about what makes a good toy. However, all their toy choices fit the eco-friendly requirement. They wanted a rubber ducky, but were concerned that many are made with *"unenvironmentally"* friendly materials. Likewise, they recommended dolls that could be made from rubberwood; trucks made of plastic that is not PVC, and stuffed animals made from organic materials, contrary to what is generally available.

Grade 3: Janae and Sally. Unlike TJ and Shantel, this third-grade dyad had difficulty engaging with the task. Their primary cognitive strategy was reading aloud (45% of strategy use), with little planning, conversation, or apparent purpose. Asking questions was used 28% of the time, most often when Sally directed questions toward the researcher rather than to her partner. Clarifying responses and reacting emotionally to information were the other two strategies used consistently. For example, a website describing the decomposition rates of different materials elicited reactions such as *"Whoa!"* and *"Horrible, just horrible!"* In the only comment that integrated her reading, in this case with a desire to act, Sally said, *"I wish there was something we could do about it."* Janae turned to her and said, *"Huh?"* Sally mumbled a repeat of her statement as she selected a different site, and Janae turned back to the screen with, *"I will read this time."* This interchange was typical of the shallow interactions that characterized their work.

As they read, Janae watched Sally's negotiation of the websites carefully, occasionally making a comment, but Sally only gave her full attention to Janae twice in 39 minutes; she appeared absorbed in the websites. Janae and Sally's social interactions involved primarily giving information (74% of interactions) in the form of reading aloud, monitoring, or clarifying; requesting information

related to task directions (13%); and reactions to the text or a comment (12%). Whereas TJ and Shantel's interactions enhanced their ability to make meaning of the text and respond to the inquiry task from a shared understanding, Janae and Sally's singular focus on the reading and lack of discussion was evident in their rationales for toy choices.

They reported that the recycled tea set and boat and the rubberwood truck and puzzles were good for *"younger children"* or *"kids would like them"* or they *"are popular"*—reasons that were explicit in the text, as was the contention that toys made from recycled materials reduce the need for cutting trees. However, they both mistakenly assumed "rubberwood" was a recycled product from reading a text that was easily misunderstood unless read carefully.

Grade 4: Matthew and Anna. This fourth-grade pair read large chunks of text—more than any other dyad—but both their cognitive strategy use and social interactions showed they attended to and absorbed the meaning of what they read more than the other fourth-grade dyad. During reading, for example, they monitored their understanding with comments such as, *"So that makes it easier . . . now we know something."* Throughout their discussion, they actively wondered about two webpages in particular that concerned PVC plastic—*"I wonder if humans make the PVC products or machines?"*—and the decomposition times of natural and man-made materials—*"I thought notebook paper would be fast."* Later in the task, they used this information as references when selecting their toys.

Matthew and Anna interacted in a consistent dialogue that functioned socially in many ways: they gave information by offering pronunciations for troublesome words, deferring to each other's choice of website, or taking turns reading. Another very typical pattern involved reacting to each other by listening carefully as new information was read aloud and responding with a string of emotional expressions of interest and surprise. For example:

Matthew: [reading aloud] *One bottle made with PVC plastic can contaminate a 100,000 non-PVC bottles when recycled together.*
Anna: *Can you believe that?*
Matthew: *No.*
Anna: *Only one PVC bottle, and it does all of that!*

Matthew and Anna's toy choices and rationales were directly linked to their reading and discussion. They chose 10 toys, wrote a list, and systematically ranked them according to their concerns about eco-friendly construction and appeal to children. Ultimately, they chose: a puzzle because it was educational, made of eco-friendly materials, and taught kids how to share; a baby rattle, also made of eco-friendly materials, that was safe to chew on and safer than *"stuff"* made with PVC; a rocking horse that was fun, wooden, and could be donated (recycled); and a size and shape learning toy that was educational.

Grade 4: Charlie and Christy. This dyad's interactions during the inquiry task were characterized by short, vague comments and superficial talk about what to read and how *"cool"* the toys were. Although their use of cognitive strategies was balanced—reading aloud; questioning the text and each other and clarifying ideas; and searching for and evaluating information—their talk was insubstantial. For example, they spoke about the names of toys, as opposed to Matthew and Anna's talk that centered on eco-friendly features. Christy sought to use a variety of strategies to engage cognitively with the task: for example, stopping to ask clarifying questions such as, *"What's that called?"* or monitoring her own thinking with statements like, *"I don't know what that means."* However, Charlie frequently continued reading without responding or offhandedly agreed with Christy's ideas while continuing to click through a website. Consequently, her strategy use was short-circuited by Charlie's lack of cognitive engagement.

Socially, Charlie and Christy appeared to take on different roles. As Charlie read aloud, most of his contributions to the conversation (64% of turns) involved giving information and occasionally building on Christy's ideas with his own interpretations. Christy also gave a lot of information (36% of turns), but, compared to Charlie, she requested more clarifications and gave more suggestions for how they should be starting to make sense of the text (e.g., *"Hold up! So what it's saying is . . . we have to make something that will decompose in less than a year"*). Like Matthew and Anna, this dyad was able to absorb some of their reading; however, they used only a few ideas in their rationales for choosing toys.

In their final choices, the dyad often couldn't call to mind the words to describe how toys worked or misunderstood the principles inherent in the ideas. For example, unpainted wood blocks were chosen because *"It's bad if you paint it because . . . it [the paint] contains something."* Charlie and Christy explained that a solar-powered cable car would appeal to children because it was powered by the sun and would turn off automatically when the sun went down (a misconception). The potato clock was *"good"* because potatoes *"come from the earth"* and *"break down."* Although Christy knew the potatoes provided the power for the clock, she said, *"I don't really know what it said, but it was a p word* (potassium)*,"* which was another misconception.

Grade 5: William and Evan. This fifth-grade pair interwove reading and discussion with a focused and substantive use of cognitive strategies. They stopped after nearly every sentence they read to ask questions, interpret meaning, and integrate the text with their reading, prior knowledge, and experiences. William was more confident of his knowledge about eco-friendly terms and manufacturing processes, but Evan was not intimidated and contributed both questions and elaborations. For example, when reading about pollutants in toys, Evan said, *"So they're* [leaky batteries] *basically like messing up, messing up the ground."* William replied, *"Cause the batteries, they're chemical energy so it was letting chemicals into the ground."* Their discussion continued with concerns about their own toys having lead paint, and William recounted a toy recall from McDonald's.

Socially, throughout the task, William and Evan balanced efforts to give, monitor, request, and react to relevant ideas that contributed to their collaborative meaning construction. In many exchanges, William and Evan shared the reading and thinking

aloud, finishing one another's phrases or simultaneously expressing their understanding. Giving information (38% of this type of interaction), interpretations (15%), and examples (10%) characterized the bulk of their talk. This typical exchange about how toys can be dangerous shows how they often used examples to integrate and comprehend new ideas they encountered in their reading:

Evan: *Like the toys, like, little kids they have . . .*
William: *They like, suck on it.*
Evan: *Yeah, and bite on it.*
William: *And they have batteries in it.*
Evan: *Sometimes bite off the paint. And they don't even know it. And . . .*
William: *They're sick.*
Evan: *Yeah, harmful stuff.*

This pair provided comprehensive rationales for toy choices that reflected inferences made while reading and talking about the information. Like other dyads, they thought rubberwood was made of plastic; otherwise, they reported that toys should not be painted with toxic dyes or lead but with water-based dyes, and that one eco-friendly toy made from cardboard was recommended by doctors and included a rattle young children would like.

Grade 5: Jack and Jill. Like William and Evan, this fifth-grade pair read and talked about the text using a balanced set of cognitive strategies including reading aloud, questioning, and clarifying ideas. However, Jack and Jill worked through the material so quickly that their final report was only partially completed as requested. They had the fewest lines of reading aloud in their transcripts (47) and only slightly more conversation (150 lines) than taciturn third-graders Janae and Sally. Comparatively, William and Evan had 66 lines of reading and 248 lines of discussion. One example of a typical fleeting thought from their discussion with little elaboration occurred when reading about PVC plastic. As Jill read aloud quickly, Jack paused to ask, *"Why can't we use PVC plastic instead of that* [organic cotton or wool]*?"* Rather than clicking on the link that would provide more information to address Jack's question, Jill simply replied, *"Maybe when you throw it away it does something,"* and moved on.

Socially, Jill initiated many of the interactions, often with a question to Jack. When reading, her reactions were often repetitive and thoughtless. For example, when Jack suggested using rechargeable batteries, she responded, *"Oh, yeah. Charge . . . charge batteries. Oh my god. That's a great idea. That's a good idea. Chargeable batteries. That's smart. How do you spell chargeable?"* When Jack read, he was more active in giving suggestions related to the direction of the search or monitoring the relevancy of the reading. As evidence of their shallow interactions, when Jill decided to include something on the list made of soy silk, Jack correctly remembered that stuffed animals were made from this material. When Jill wrote "soy silk sheets," which was clearly not a toy, Jack did not protest. Compared to William and Evan's serious discussions about materials in toys and toy safety, Jack and Jill's conversation was often inconclusive, which was reflected in their toy choices.

The dyad offered four choices, each related to the idea of being green. Only one choice, however, was a toy: a biodegradable car that could be thrown away when children tired of it. Their other choices were a solar-powered laptop that uses less energy (Jack made this up), a soy silk bedspread (drawing on Jill's knowledge of soybean byproducts), and biodegradable cotton clothes.

Characterizing More and Less Productive Interactions Across Grade Levels

In this section, we report findings across all six dyads to highlight contrastive cases that were considered more or less productive for advancing online inquiry across all three grades. After synthesizing common patterns within each cluster of three dyads, a selected video segment was used to represent common patterns observed across dyads in that cluster in terms of level of cognitive engagement and quality of collaboration.

Commonalities across more productive interactions. After ranking our selected subset of six dyads on a two-dimensional continuum of how partners socially co-construct knowledge during online inquiry (see again Figure 1), our findings suggested that those students who simultaneously exhibited higher degrees of cognitive engagement with the content and mutually collaborative social interactions with each other were better able to accomplish the task. These students' interactions (see TJ & Shantel, Grade 3; Matthew & Anna, Grade 4; and William & Evan, Grade 5) were richly evident of strategic online reading and collaborative thinking. These dyads balanced social exchanges involving giving (of information, interpretations, and support) and reacting (accepting their partner's previous contributions) while cognitively determining important ideas, extending each other's ideas, and then integrating relevant information within and across websites.

As an outcome of their reading and interactions, these more productive partners were able to provide examples of four toys from their search or previous personal preference that met the task criteria for eco-friendly materials. They read the overview page, actively discussed its contents, strategically clicked on links in the overview page, and examined those pages too. In addition, their searches were focused on relevant texts, and their oral rationales at the end of the task included details from their readings and discussion. Finally, these pairs used the affordances of working with a partner to enhance their joint negotiation of the task and their co-constructed understanding of eco-friendly toys.

To illustrate the types of extended interactions typical among these more productive dyads, we selected a segment from William and Evan's transcript (see Table 2). This fifth-grade dyad was highly productive in their focused search for information, their reading and discussions, and their preparation of a report of their findings. Socially, the boys managed their work with cordiality and consideration. Typically, one or the other read a few lines, and the reading spurred a comment, a connection, or a question.

The following segment took place four minutes after the students began the task. After William read a section, "Don't buy any-

thing made of PVC plastic," Evan began the exchange by asking, *"What is PVC?"* (Line 95). Because of William's courteous manner, Evan was willing to ask his opinion (Lines 97–98). William asked the researcher's permission to click on embedded links, and the pair eagerly perused the new page. The boys briefly scanned the text, then Evan read a phrase and William followed with another phrase in a typical manner (Lines 102–103). They engaged in rapid back-and-forth talk that involved reading, inferring, agreeing, and connecting the PVC acronym with the chemical term (Lines 103–110). During this portion of the exchange, they shared the reading and thinking aloud, finishing one another's phrases or simultaneously expressing their understanding. Throughout the segment, they jointly clarified the meaning of the reading and applied it to the task, building on each other's previous comments. They summarized by stating that they didn't want PVC to be in any of the toys they selected for the task (Line 115).

Commonalities across less productive interactions. In contrast to these more productive types of interactions, our findings also

Table 2. Summary of More Productive Cognitive and Social Exchanges Between Two Fifth Graders Reading Within the Overview Page Before Conducting Their Inquiry

Social Moves	Line #	Name	Dialogue	Cognitive Moves
Gives information	88–89	William	(William has just finished reading.) *Don't buy anything made of PVC plastic. Choose toys that are made of natural or biodegradable materials that will not damage the earth.* (followed by a short discussion of the term, biodegradable.)	Reads aloud; Clarifies a term
Requests clarification	95	Evan	Question. *What is PVC?*	Asks question
Expresses uncertainty; Extends	96	William	*I don't know. I have no idea.*	Monitors understanding
Monitors; Extends	97–98	Evan	*I never knew what that was. I just like, see it. I don't know what it is or something.*	Monitors understanding
Gives suggestion	99	William	*Let's ask if we can click on that. It might tell us something.*	Repairs reading path; Infers utility of website
Gives information	102	William	*Some people say it's poison plastic.*	Reads aloud
Gives information	103	Evan	*Billions of pounds of PVC is poison plastic.*	Reads aloud
Gives clarification	103	William	*So, it's like…*	Interprets
Gives clarification	104	Evan	*Basically.*	Agrees
Gives clarification	105	William	*plastic with…*	Interprets information
Gives clarification	106	Evan	*chemicals.*	Interprets information
Gives clarification	107	William	*really bad chemicals.*	Interprets information
Expresses understanding	108	Evan	*Oh, right there* (pointing to the page)	Connects text w/ initial question
Gives information	109	William	*Polyvin…* (Evan continues to skim while William takes over reading)	Reads aloud
Gives information	110	William	*Polyvin chlorifide plastic.* [polyvinyl chloride]	Reads aloud
Expresses understanding	111	Evan	*That's what it is!*	Monitors; Connects explanation to question
Expresses understanding	112	William	*Oh, that's what it stands for.*	Monitors; Connects explanation to question
Gives interpretation; requests confirmation	113	Evan	*So is it sort of like nuclear waste, like, sorta kinda?*	Interprets in light of reading and prior knowledge
Gives opinion & clarification	114	William	*Almost, but not as bad. Yeah, it's not as bad as nuclear waste.*	Interprets
Gives opinion & clarification	115	Evan	*Yeah, we don't want that.*	Supports previous interpretation

suggested that those students who exhibited (a) lower degrees of cognitive engagement with the content that overlapped with (b) fewer mutually collaborative social interactions with each other were less successful. That is, pairs of students who simply read the overview page with little or no meaningful discussion and those who immediately began a search without exploring the links were less successful supporting their choices of four toys (see Sally & Janae, Grade 3; Charlie & Christy, Grade 4; and Jack & Jill, Grade 5). These less productive partners took turns giving (e.g., reading aloud and offering opinions) and occasionally reacting to information. However, compared to the more productive pairs, they engaged in far fewer elaborative interactions with the text and with each other that involved higher-level cognitive strategy use or the joint construction of new ideas.

Consequently, although these dyads provided examples of toys when prompted, their rationales were neither varied nor rich. Furthermore, in one case, the items were not even toys but environmentally friendly sheets and clothes. These students did not appear to use the affordances of the overview page to structure their learning and searches or their subsequent oral rationales to justify their choices. In addition, their dialogue did not appear to enhance their ability to effectively navigate within multiple websites or generate new insights about eco-friendly toys.

The segment selected from Charlie and Christy's (Grade 4) transcript illustrates a typical exchange between less productive partners as they read within the overview page. The pair began by discussing the relevance of the items listed in a link connected to the overview page. This exchange (Table 3) occurred early in the inquiry task, where we observed one of several occasions where partners read aloud portions of the web page but failed to listen deeply to each other's questions and contributions before moving to the next section. As a result, the dyad moved quickly from one idea to the next without a deep connection to task relevancy.

As observed in three other interchanges between these two partners, Christy attempted to contribute new ideas (Lines 175, 177, 179) that integrated information from the text with her own opinions. Her contributions moved them closer to making decisions about eco-friendly toys. However, in this case, Christy suggested making a toy out of plastic, wrongly inferring that the longer an item takes to decompose, the better that material

Table 3. Summary of Less Productive Cognitive and Social Exchanges Between Two Fourth Graders Reading Within the Overview Page Before Conducting Their Inquiry

Social Moves	Line #	Name	Dialogue	Cognitive Moves
Gives information	173–174	Charlie	[continues reading aloud]… *Wooden baseball bat - 20 years. Leather baseball glove - 40 years. Steel can - 100 years. Aluminum soda can - 350 years.*	Reads aloud
Gives suggestion	175	Christy	*So we should make something…like…*	Integrates: Working toward action
Ignores; Gives information	176	Charlie	*Plastic sandwich bag - 400 years*	Reads aloud
Gives suggestion	177	Christy	*We should make something like that. That's made of… out of probably a plastic*	Integrates: Working toward action
Ignores; Gives information	178	Charlie	*A plastic six-pack ring*	Reads aloud
Gives interpretation	179	Christy	*So it can…like…*	Attempts to interpret information
Ignores; Gives information	180–181	Charlie	*450 years. Polystyrene foam cup - Maybe never. Car tire - Maybe never.*	Reads aloud
Gives information	182	Christy	*Glass bottle - Maybe never*	Reads aloud
Gives interpretation	183–184	Charlie	*So we should probably make something that's like a wooden baseball bat that's made out of that because it will never decompose.*	Interprets information
Gives information	185	Christy	*Wood will decompose after 20 years if it's left outside….*	Reconsiders interpretation
Gives counter-suggestion	186	Charlie	*But, think of children…* [suggesting they aren't children for 20 years]	Reconsiders interpretation
Accepts contribution	187	Christy	*Yeah it will last long for them.*	Supports interpretation
Gives suggestion	188	Charlie	*Or maybe something made of like aluminum.*	Reconsiders interpretation
Accepts contribution	189	Christy	*Yeah.*	Supports interpretation
Gives opinion or judgment	190	Charlie	*That will last…a pretty long time*	Supports interpretation

would be for an eco-friendly toy. Charlie, on the other hand, ignored her suggestions and continued to read aloud (Lines 173, 176, 178, 180). Christy then resorted to reading the next line of text aloud (Line 182), perhaps in an attempt to be recognized. Finally, Charlie offered a toy suggestion (Line 183), most likely picking up on Christy's faulty logic that long-lasting materials make the best eco-friendly toys. At this point, Christy took on a supporting role, clarifying details about how long wood lasts but ultimately agreeing with Charlie's faulty choices of toys made of long-lasting wood or aluminum.

Unique patterns across more and less productive interactions. Overall, each dyad in this focus study reflected a social and cognitive "dyadic fingerprint" that highlighted the uniqueness of the participants. In the more productive pairs (i.e., TJ & Shantel, Grade 3; Matthew & Anna, Grade 4; and William & Evan, Grade 5), the discussions around the task were deeper, the reading of the task more strategic, and the collaborations more productive. All three dyads in this category maintained a high level of cognitive engagement. Yet differences were observed as well. TJ and Shantel approached the Green Toys Shop task from a more "efferent stance" (Rosenblatt, 1978), constantly referencing their reading, monitoring their thinking, making connections, and checking for understanding. William and Evan approached the task with eagerness and significant prior knowledge about the concept of pollution. They were considerate and collaborative as they worked together to provide strong rationales for their toy choices. Comparatively, Matthew and Anna are characterized as very engaged readers, reacting emotionally to numerous ideas they read and thoroughly reading and discussing websites they encountered. They wandered the most explicitly beyond the text compared to other more productive dyads.

Some interaction patterns among the less productive dyads (i.e., Janae & Sally, Grade 3; Charlie & Christy, Grade 4; and Jack & Jill, Grade 5) can also be described as unique. Janae and Sally, for example, spent more time reading aloud but failed to go beyond the text to discuss their reading with any depth or level of engagement. They were confused by the task and needed prompting and interpretation from the instructor to refocus. Their searches were few and short lived, with little discussion that was relevant to the task. Jack and Jill, on the other hand, seemed connected to the content of the inquiry but not to each other. This yielded short-lived searches and shallow discussion as each struggled to produce the next toy choice. Charlie and Christie can be characterized as readers who jumped into the task but lacked a plan of action. They tended to do more straight reading with little discussion of relevance to the inquiry. Their conversations focused more on reading toy labels and deciding where to navigate next, with very little processing and discussion of what was read. This led to sudden changes in direction of task and little time spent in rich critical discussion. These unique dyadic fingerprints will guide future research agendas to better serve online readers at many grade levels.

DISCUSSION

This study sought to better understand how pairs of upper elementary students cognitively and socially engaged with each other during structured online inquiry. We also wanted to highlight patterns of cognitive strategy use and social interaction that appeared to be more and less productive in advancing online inquiry. Overall, although grade level differences were apparent across the dyads, it was clear that grade level alone did not explain the differences in the interaction patterns. Similarly, examining pairs' cognitive or social interactions exclusively was not an adequate means of characterizing the complex interactions that occurred amongst partners during online inquiry. Instead, our findings add to earlier work to suggest the dialogue that unfolds during online inquiry is a complex set of interactions that requires careful reflection on cognitive, social, and developmental aspects.

Similar to studies of comprehension in printed text environments (e.g., Alexander & Jetton, 2000; Pressley & Afflerbach, 1995) and studies of online text processes (e.g., Cho, 2011; Coiro & Dobler, 2007; Dwyer, 2010; Goldman et al., 2012), findings from this study suggest that cognitive strategies required for more productive interactions during online inquiry include a number of higher-level reading processes that involve inferring, integrating, evaluating, and interpreting what is read. Summarizing and synthesizing important ideas from reading to make informed choices were also important. Partners who actively engaged in discussions intertwined with these cognitive strategies further deepened their thinking about content they needed to complete the task. In contrast, pairs who spent their time reading aloud with little discussion of the content were less apt to use any cognitive strategies to make sense of their reading. As a result, they appeared to reflect very little on what was read and were less able to apply a range of cognitive strategies to support meaning making.

Social practices observed in productive dyads, regardless of grade level, included listening actively, weighing in on decisions about where and how to navigate through online texts, and using prior knowledge to make connections and extend thinking. When pairs were able to engage in quality dialogue focused on exchanging information, giving interpretations, offering clarifications or suggestions, and providing examples based on what they read, productive collaboration occurred. Productive pairs frequently stopped reading to unpack the material they read, make connections to their prior knowledge, and integrate what they read with what they already knew from personal experiences in order to make meaning. These interactions unfolded in a back-and-forth manner that was focused on engaging with the content and completing the task. In contrast, less productive pairs read the content straight through with little discussion, didn't listen actively to their partner's suggestions and ideas, and thus struggled with integrating ideas that emerged from text and discussion. These findings support work by others exploring the quality of talk in school settings (Foster, 2009; Kiili et al., 2012; Mercer, 1995; Soter et al.,

2008; Wells & Arauz, 2006) and point to the important role of classroom talk for guiding the development of understanding in online learning spaces.

CONCLUSIONS AND NEXT STEPS

Our purposive sampling of six contrastive cases at three different grade levels enabled us to closely examine contrasting aspects of cognitive expertise and social collaboration as part of online inquiry. While this sampling decision provided rich insights into the complexities involved when young partners talk together to negotiate meaning across online texts, a limitation is that these findings cannot be generalized to the whole range of interaction patterns that teachers may encounter in their work with students in Grades 3–5. However, with new insights about how to cross-code students' cognitive strategy use and social interactions within the same reading events, we look forward to extending our application of the cognitive and social coding schemes developed within this study to other inquiry tasks with a wider range of children. Such analyses may more accurately represent a wider range of patterns across the continuum of more and less productive interactions likely to occur among upper elementary students during online inquiry.

Nevertheless, the picture that has emerged thus far with data presented in this study demonstrates that pairs of third, fourth, and fifth graders working collaboratively to complete a structured online inquiry task were able to provide responses to the information problem about environmentally friendly toys, and that these dyads exhibited varying characteristics of more or less productive social and cognitive engagement. These patterns suggest that some upper elementary school students may prosper, while others are likely to struggle while engaging in the types of co-constructive inquiry-based reading experiences set forth as requisites for future academic success (see Assessment and Teaching of 21st-Century Skills [ATC21S], 2008; Common Core State Standards Initiative, 2010).

Thus, our findings bring new energy to the need for interventions to ensure all students meet the expectations of college- and career-readiness in a digital information society. When a skilled teacher can spot less productive behaviors among dyads, a series of supports can be enacted to increase the cognitive growth that may occur when students engage in collaboration to complete an online inquiry task. Much more research is needed, however, to test the efficacy of intervention scaffolds for guiding students through points of difficulty they may encounter during online research and inquiry-based reading experiences. The current study moves us one step closer to better understanding the nuances of productive, collaborative online inquiry so we can turn our attention to designing instruction and digital scaffolds that may foster these practices as part of classroom reading experiences in elementary school settings.

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Julie Coiro is an associate professor in the School of Education at the University of Rhode Island. Professor Coiro can be reached at jcoiro@mail.uri.edu.

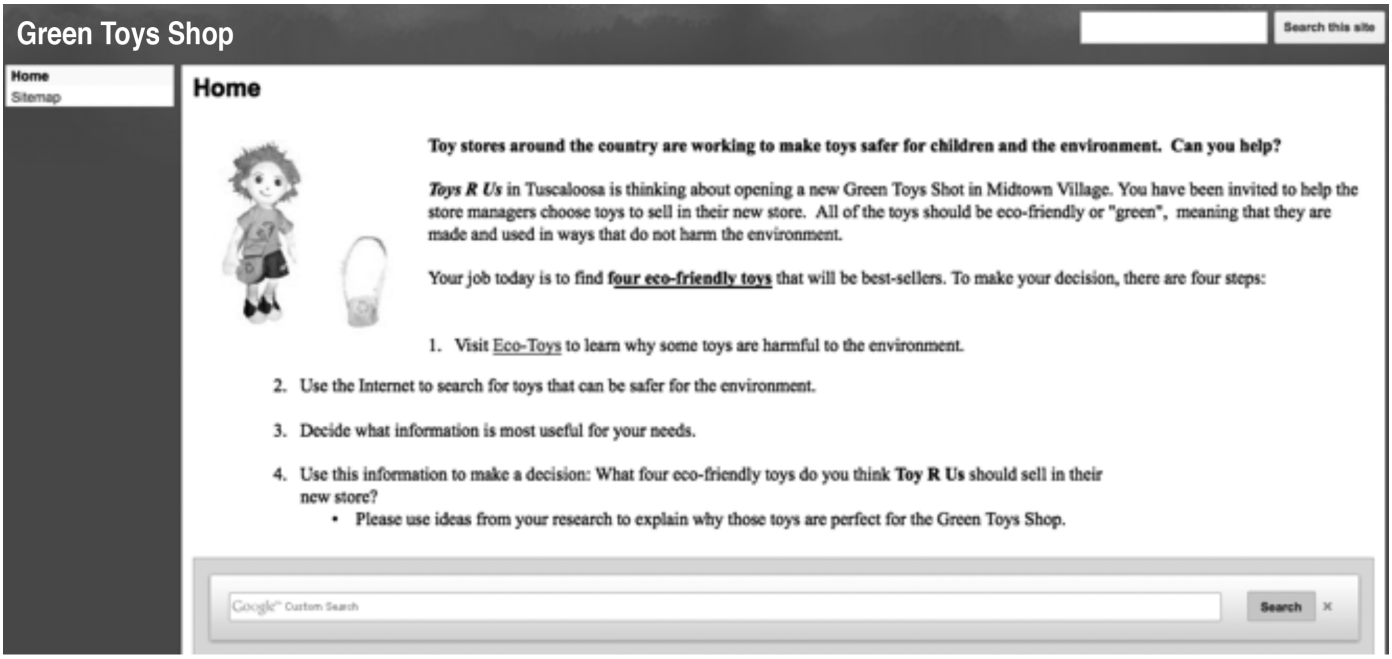
Diane Carver Sekeres is an associate professor of literacy and elementary education in the Department of Curriculum and Instruction at the University of Alabama. Professor Sekeres can be reached at dsekeres@bamaed.ua.edu.

Jill Castek is a research assistant professor with the Literacy, Language, and Technology research group in the Department of Applied Linguistics at Portland State University. Professor Castek can be reached at jcastek@pdx.edu.

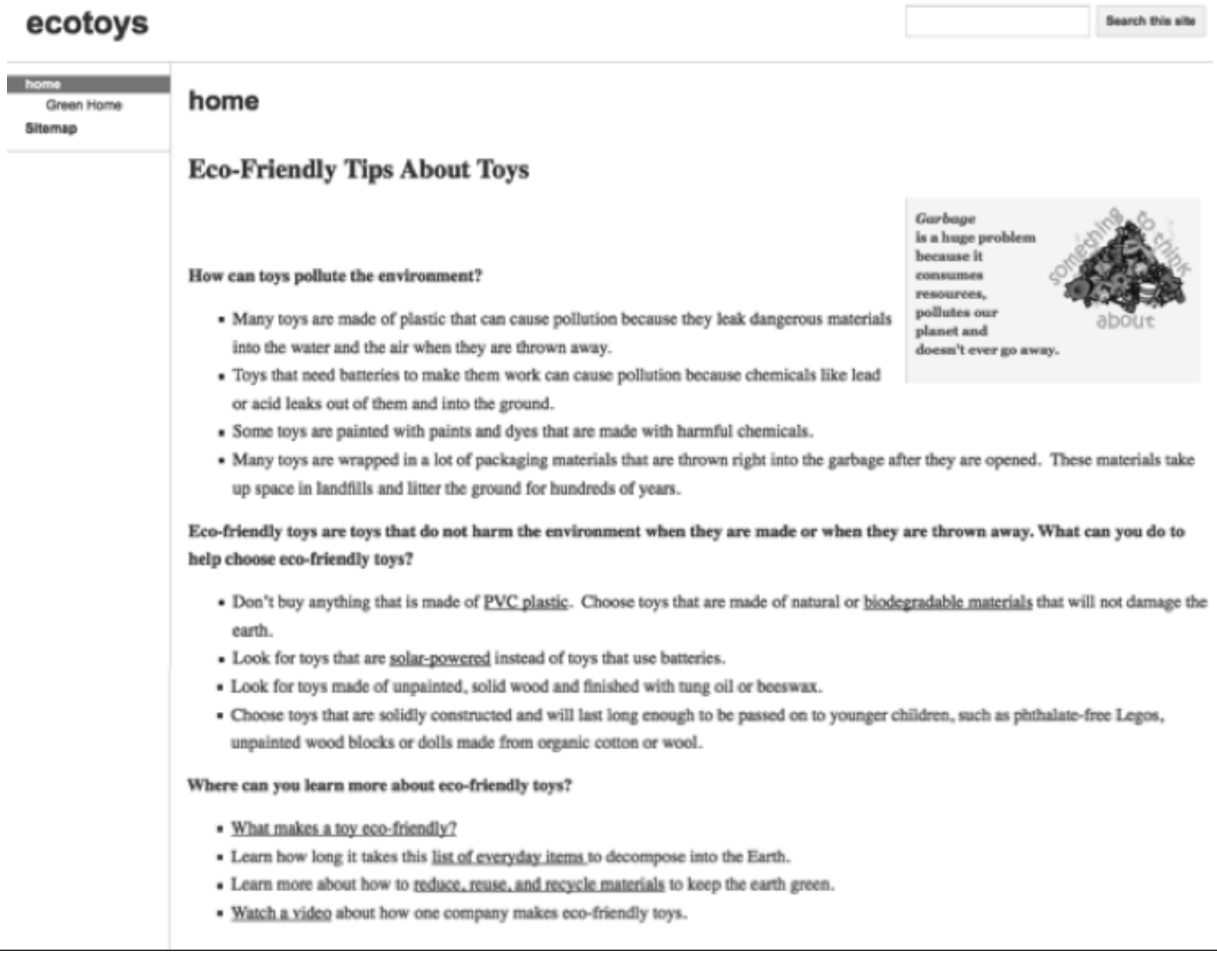
Lizabeth Guzniczak is a visiting assistant professor in the Reading and Language Arts Department at Oakland University. Professor Guzniczak can be reached at guznicza@oakland.edu.

APPENDIX A

Task Directions



Overview Page



APPENDIX B

Cognitive Coding Scheme for Strategic Online Reading Processes	
PREREADING **Planning** • Planning for partner work • Planning materials and logistics • Activating prior knowledge • Anticipating the search • Planning the search • Identifying search goals **Searching** • Generating keyword search • Scrutinizing search result link utility • Scrutinizing website link utility • Predicting hyperlink utility • Selecting websites from previous search **Overviewing** • Overviewing • Sampling initial texts **DURING READING (within a website)** **Determining Important Ideas** • Adjusting reading speed • Reading aloud • Reading silently • Listening to video • Skimming • Predicting • Paraphrasing accurately • Paraphrasing with misconception • Following with cursor • Highlighting with cursor • Discussing website images • Avoiding text • Sequencing hypertexts **Questioning** • Asking questions about text meaning • Clarifying text meaning • Determining word meaning	**DURING READING (continued)** **Inferring** • Inferring • Connecting key ideas within text • Connecting key ideas to prior experiences • Connecting to prior knowledge • Connecting key ideas across texts **Integrating** • Interpreting • Supporting interpretation • Reconsidering interpretation • Reconsidering prior knowledge • Summarizing for meaning • Synthesizing • Remembering • Working toward action **Evaluating** • Evaluating utility/relevance • Evaluating accuracy/plausibility • Evaluating author's level of expertise • Evaluating author's perspective • Reacting emotionally • Evaluating with surface-level information **Monitoring** • Monitoring understanding • Monitoring strategy use • Verbalizing strategy use • Monitoring reading pathways • Monitoring spelling • Monitoring task description **Repairing** • Changing reading strategy • Changing reading path • Reconsidering alternative search • Selecting other websites from search results • Conducting extended search • Conducting alternative search

Adapted from Pressley. M., & Afflerbach, P. (1995). *Verbal protocols of reading: The nature of constructively responsive reading.* Hillsdale, NJ: Erlbaum and Author (2012).

APPENDIX C

Social Coding Scheme for Functions of Dialogic Interactions During Online Inquiry	
FUNCTION: GIVE • Give apology • Give clarification or definition • Give counter-suggestion/rebuttal) • Give evaluation/opinion/judgment • Give example • Give help or support • Give information • Give interpretation • Give justification/explanation • Give self-nomination (I'll do that) • Give/delegates partner (You do that) • Give/repeat previous contribution • Give suggestion • Give summary • Give "Yes" or "No" answer **FUNCTION: REQUEST** • Request confirmation (Isn't that . . .) • Request clarification (Do you know. . .) • Request nomination (Can I do that?) • Request justification/explanation • Request repetition • Request suggestion • Request to speak • Request opinion • Request "Yes/No" answer	**FUNCTION: MONITOR** • Express uncertainty or confusion • Express understanding **FUNCTION: REACT** • Accept previous contribution • Disagree with previous contribution (but no counter-suggestion offered) • Express surprise • Express interest • Express impatience • Express boredom • Ignore other contribution • Reject previous contribution

Adapted from Foster, J. (2009). Understanding interaction in information seeking and use as a discourse: A dialogic approach, *Journal of Documentation, 65*(1), 83–105.