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Sourcing on the internet: Examining the relations among different phases of online inquiry

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ABSTRACT

This study examined students' engagement in sourcing throughout online inquiry, that is, when they specified the information need, formulated search queries, evaluated online texts, and composed a written product. Participants are 167 upper secondary school students. Students completed an online inquiry task in a restricted online environment that utilized authentic online texts. Students' prior topic knowledge and reading fluency was measured and controlled for in the analysis. The results showed that students engaged in sourcing even in the earliest phases of online inquiry. A sequential regression analysis indicated that the more frequently students engaged in sourcing in specifying the information need and in search querying, the more frequently they engaged in sourcing when judging the credibility of online texts. Further, the more frequently students engaged in sourcing in their credibility judgments, the more frequently sourcing also was observed in their written products. The results suggest that students would benefit from instruction emphasizing that sourcing is a continuous process throughout online inquiry.

1. Introduction

Increasingly, people turn to the internet to find information to help them make important personal or professional decisions. For example, during the COVID-19 pandemic, many have sought information online about the safety of different vaccines to determine whether and when to get one. Such question-driven investigation, in which readers seek information and learn from multiple online resources, is sometimes referred to as *online inquiry*. In online inquiry, readers seek information to address a problem or question using information found online, and they often create a new written or multimodal product to communicate the results of online inquiry to others [25,48,60]. Thus, in online inquiry, reading and writing are intertwined practices that serve learning from texts. Even though inquiry learning is sometimes associated with science learning where students conduct experiments, make observations, and collect information to discover underlying scientific principles [46], online inquiry is increasingly becoming a common practice across different disciplines, such as science [81,77], history [17,21], and the social sciences [35,42].

Unfortunately, however, because anyone may publish what they wish on the internet, information found online is not always true. In fact, particularly in recent years, the rapid spread of misinformation and disinformation on the internet has compelled internet readers to examine information accuracy closely [40,67]. Thus, learning from accurate online information hinges on a reader's ability to evaluate the credibility of information. To do so, readers often engage in a practice known as sourcing [13]. Sourcing – attending to, representing, evaluating, and applying information about the source (i.e., author, publisher) of the text [53] – assists students in selecting and reading credible online information and learning from multiple online texts (31,66,77). Attending to sources prompts readers to consider who and what to believe when using online information for decision-making and learning [67].

Consequently, the reading research community has been particularly interested in how students source when they select what to read, evaluate the credibility of online information, and use online information to solve problems [12]a; [37]. Studies on sourcing have made important contributions to our understanding of how readers use source information to help them evaluate the credibility of online information. However, these studies have mainly focused on sourcing as an isolated process, examining sourcing during only one or two of the online in-

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quiry phases at a time. In fact, sourcing appears to occur as an iterative process throughout online inquiry that is integrated with other comprehension processes [19]. Thus, we lack a full view of how sourcing appears throughout different phases of an online inquiry task that include specifying an information need and locating, evaluating, synthesizing and communicating information [48] and of how sourcing in the earlier phases of the inquiry contributes to sourcing in the latter phases. The present study aims to investigate sourcing from this more holistic perspective. Given that research suggests that many students struggle to evaluate the accuracy and credibility of online information (e.g., [26,31]) this is important to understand so that we can better inform instruction.

2. Theoretical framework

The present study examines sourcing during online inquiry at the crossroads of two theoretical frameworks: a Documents Model framework [15,16,59] and an Online Research and Comprehension framework [48]. The Documents Model framework explains how sourcing helps readers to construct an accurate and coherent mental representation across multiple texts, while the Online Research and Comprehension model describes the processes specific to multiple texts comprehension that takes place on the Internet.

The Documents Model framework describes how skillful readers make meaning from multiple texts, that is, how readers form a coherent representation from multiple texts [15,16,59]. According to this framework, the readers form two types of representations: an integrated mental model and an intertext model. The integrated mental model represents content across the texts and reflects students' conceptual understanding of the topic. The intertext model accentuates the role of sources when readers build an understanding of multiple texts that often represents different perspectives and potentially conflicting views about a topic. To form the intertext model, readers attend to sources and their relations to pieces of information. As a result, the intertext model includes two types of links representing these relations [10,62]. First, source-content links represent how specific source information is related to text content (e.g., "Source A says…"). These links assist readers in differentiating texts, evaluating their credibility, and interpreting their content. Second, source-source links represent relationships between the sources (e.g., "Source A agrees/disagrees with Source B"), assisting readers in comparing and contrasting text content in light of their sources. With the help of the intertext model, readers can evaluate the sources and text content, organize conflicting views, and resolve the potential conflicts in their integrated mental model (see also [8, 69]).

Online Research and Comprehension, or online inquiry, as we label it in this work, is a process where readers solve a problem or learn about a specific topic by examining multiple online texts. During online inquiry, readers specify their information need, locate, evaluate, synthesize, and communicate information [47,48]. We use the term online inquiry, rather than online reading or other such terms, to underscore the point that learning from texts in online contexts typically involves not just reading but also writing, or creating [25]. Readers not only make meaning from text but also input search terms, communicate ideas, and often use what they have learned to develop a written product [48, 60]. Online inquiry begins when readers specify an information need and make a plan to fulfill it. After making a plan for online inquiry, readers begin to locate relevant websites, which often happens with the help of a search engine. While locating relevant information and exploring websites, readers need to evaluate the relevance and credibility of online information by attending to sources and quality of content [29].

Because the purpose of online inquiry is to learn and understand complex issues, it requires readers to synthesize information from multiple online texts [22], that is, to build an integrated mental model and an intertext model. A study by Kiili and colleagues [44] showed that identifying main ideas from a single online text and synthesizing information across the texts were separate but highly correlated constructs.

Finally, readers may often create a product of some form (e.g., written or multimodal product) to communicate the results of online inquiry to others. When communicating ideas in writing, it is likely that synthesizing of ideas from multiple texts continues [5]. This happens, for example, when readers cite their sources to communicate the origin of information and justify their statements [71].

The Documents Model framework was introduced at the end of the '90s, before the rise of the Internet around 2000 [59]. However, it has been actively applied to examine the role of sourcing, in particular, in evaluation of online information [32,63], and synthesizing and communicating information in written products [4,63,74]. In the next section, we first describe the research that has examined sourcing during different online inquiry phases, and we then turn to those issues in online inquiry where sourcing is still under examined.

3. Previous research of sourcing during online inquiry

Research on sourcing has centered around three lines of research, all of which have conceptualized and examined sourcing as occurring at relatively isolated and distinct points of the online inquiry process rather than as a process that occurs throughout online inquiry (see [12]a for review). Moreover, studies have focused on sourcing during the latter phases of online inquiry, ignoring important sourcing opportunities that occur at the earlier stages of online inquiry.

The first line of research on sourcing has examined how sourcing appears during the specific online inquiry processes. When locating information and selecting links from the search engine results page, readers attend to source features (e.g., in URLs) to make initial inferences about the credibility of potential websites [20,30]. However, readers quite rarely rely on source features in their selection of information sources but tend to rely more on content relevancy [49]. According to Salmerón, Kammerer, and García-Carrión [64], readers often rely on top-link heuristics, (i.e., favouring links higher in position in search results) when locating information from search results pages, but do engage in more systematic processing when selecting information sources for later use, such as writing an essay or making a decision.

The search engine result page provides readers with limited amounts of information about a website. When readers open a website, additional source features (e.g., credentials, document type, author's intentions) can be used to make more accurate judgments about the credibility of the website (cf. [59]). However, spontaneous sourcing while reading and evaluating online texts [38,75] and writing a synthesis from them (e.g., [42,58,63]) has also been found to be quite limited among students. Prompting students to source during online inquiry may activate them to put their source knowledge into action [49, 57]. This, in turn, may have a positive effect on locating reliable information sources [7] as well as on deep reading and learning from online information sources [4,31,77].

The second line of research has examined the associations between sourcing at different points of the online inquiry process. For example, List et al. [49] showed that the more students relied on epistemic justifications for their selection of information sources (including justifications by reliability, authority, or document type), the more often they cited their sources and presented arguments in their responses to open-ended inquiry questions. Further, additional think-aloud studies have shown positive relations between evaluation of sources during the reading of multiple texts and sourcing in essays [2,4,72]. For example, Anmarkrud et al. [2] found that the more actively students evaluated texts during reading, the more citations and source-content links they included in their argumentative essays. The active engagement with sourcing during reading has also been found to be associated with higher quality of argumentative reasoning in students' essays [2,4].

The third line of research has examined individual differences in sourcing during specific online inquiry phases. Individual differences, such as basic reading skills and prior knowledge, may play a role in locating, evaluating, synthesizing, and communicating information from

multiple online texts (see [12]a; [65]). In the present study, we controlled for reading fluency and prior topic knowledge for the reasons described below.

Reading fluency may be an important underlying factor in online inquiry because online inquiry requires a considerable amount of reading. Readers need to examine search results, skim multiple texts to inform the selection of relevant and credible texts, and engage in close reading of multiple texts to make meaning. Thus, online inquiry may set more requirements for reading fluency compared to reading a single text [3]. Fluent reading may free readers' cognitive resources to pay attention to source information. Consequently, reading fluency has been shown to be positively associated with evaluation of search engine results [33] and online texts [43] as well as synthesizing [1] and communicating online information [39].

In reading research, it has been widely agreed that prior topic knowledge plays a facilitative role in reading comprehension [18]. Accordingly, it is assumed that prior topic knowledge also facilitates intertextual inferencing and creation of coherence across divergent texts [9]. In particular, studies comparing novice and expert performance have shown the advantage of expert knowledge in sourcing both in offline [78] and online contexts [7,51].

As shown above, sourcing activities have been studied from multiple perspectives, with studies illuminating sourcing processes and underlying individual differences during specific phases of online inquiry. However, less is known about sourcing during the earliest phases of online inquiry, in other words, whether students attend to sources when specifying their information need and whether students utilize source information when formulating search queries to locate credible information. Although multiple studies have investigated terms students use in their search queries (i.e., query formulation), they have focused on terms relevant to the content of the task [27,76]. Little is known about how readers use specific sources (e.g., name of a specific source) or source features (e.g., author profession, such as researcher or doctor) to restrict their queries. Moreover, to our knowledge, no studies have examined sourcing throughout the entire online inquiry process.

Therefore, in this study, we examine sourcing when students specify their information need; formulate search queries to locate information; judge the credibility of sources to evaluate information; and use sources when composing a written product. Particularly, we are interested in how sourcing during the earliest online inquiry phases predicts sourcing in the latter phases. For instance, we are interested in how sourcing in search queries is related to sourcing in credibility judgments as well as further sourcing in written products.

4. Present study

The present study addresses three research questions: 1) How frequently did students engage in sourcing during different phases of online inquiry? 2) How did sourcing in specifying the information need and sourcing in search queries predict sourcing in students' credibility judgments of online texts? 3) How did sourcing in specifying the information need, in search queries, and in credibility judgments predict sourcing in written products? When examining Research Questions 2 and 3, we controlled for reading fluency and prior topic knowledge. Past research has shown that both prior topic knowledge [12,38] and offline reading skills [28,33] contribute to readers' evaluation of online texts as well as to sourcing and comprehension when reading multiple documents [11].

Research Question 1 is explorative in nature and it aims to clarify how frequently students engage in sourcing during different phases of online inquiry. There is almost no research on students' sourcing when specifying the information need and formulating search queries. However, we expected to observe at least some sourcing in all online inquiry phases, providing the basis for Research Questions 2 and 3. In terms of Research Question 2, we expected that sourcing in specifying the information need and sourcing in search queries are positively related to

sourcing in credibility judgments. When readers specify their information needs, they can set goals and plans related to the information that they think would help them to solve a problem or complete the task. These kinds of considerations are part of the readers' representation of the task, i.e., a task model. According to Britt, Rouet and Durik (15, p. 151), "the variability in task model representation will systematically influence readers' activities and the eventual representations they construct." We also expected that if readers already think about sources when formulating search queries, they will also engage in sourcing when evaluating online texts.

In terms of Research Question 3, we expected that sourcing in the information need and formulation in search queries further contribute to sourcing in written products. We also expect that sourcing in credibility judgments of online texts positively relates to sourcing in written products [4,2,72].

5. Methods

5.1. Participants

Participants were recruited from eight Finnish schools whose language arts teachers volunteered to participate in the study. The students were selected from the obligatory language arts course "Text and influence," the objectives of which are defined in the national curriculum [56]. The participating eight schools represented bigger cities (2 schools, over 250,000 recidents), middle size cities (4 schools from the city with about 70,000 recidents) and municipalities (2 schools from a municipality with about 16,000 residents) in Finland. The grade point averages of entrance for these schools in 2017 varied from 7.00 to 8.75 (the required average for five schools was between 7.00–7.50, one school 7.83, and for two schools over 8). The required grade point average across Finland ranged from 5.92 to 9.91 (https://vipunen.fi/en-gb/).

Participants were 167 upper secondary school students (57% females). Students' mean age was 17.34 years ($SD = 0.42$). All students in the class did the reading tasks, but only responses of those students who gave informed consent were used for the research purposes. If a student was underaged, consent was also received from guardian/s.
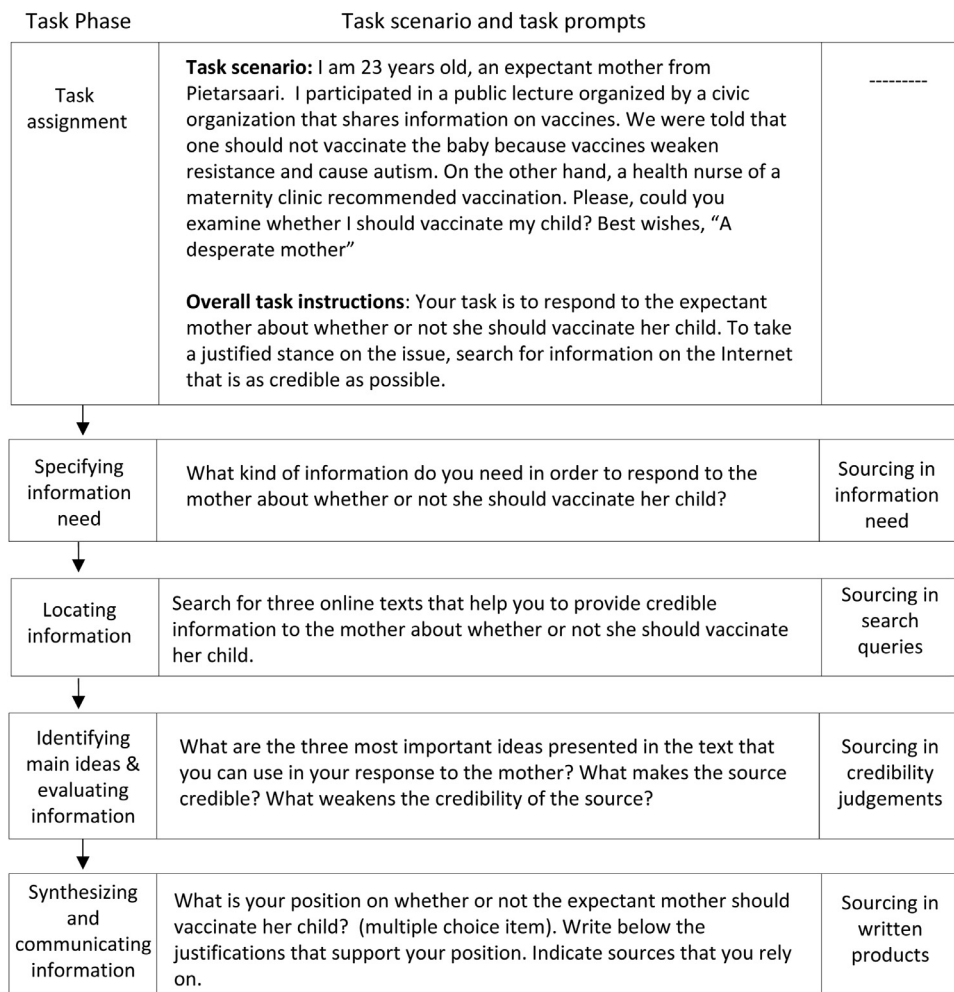
5.2. Measures

5.2.1. Prior topic knowledge

To assess students' prior knowledge of vaccines, we used a prior topic knowledge measure that has been previously developed and tested [45]. Students were shown ten statements on vaccination. From these statements, three were correct (e.g., Sufficiently extensive vaccinations protect also those people from diseases who have not been vaccinated for one reason or another), and seven were incorrect (e.g., It is unnecessary to vaccinate against milder pox diseases). Students were tasked with selecting the three statements that they considered correct. They were credited with one point for each selected correct statement or non-selected incorrect statement. Four items were too easy (over 92% of students responded correctly) and they were excluded from the final measure. Thus, the maximum score of the prior topic knowledge measure was 6. The reliability was estimated with a latent variable modeling approach that is suitable for binary items [61]. The reliability was 0.66 with 95% *CI* [.53–.79].

5.2.2. Reading fluency

We used the word chain test to measure students' reading fluency [36]. The test consisted of 25 word chains, each containing four words without interword spaces. Students were tasked to separate the chains into primary words as quickly and accurately as possible within the 90 s time limit. The maximum score of the test is 100. According to the test manual, the test-retest reliability coefficient of the test varied between 0.70 and 0.84.

Task Phase	Task scenario and task prompts	
Task assignment	**Task scenario:** I am 23 years old, an expectant mother from Pietarsaari. I participated in a public lecture organized by a civic organization that shares information on vaccines. We were told that one should not vaccinate the baby because vaccines weaken resistance and cause autism. On the other hand, a health nurse of a maternity clinic recommended vaccination. Please, could you examine whether I should vaccinate my child? Best wishes, "A desperate mother" **Overall task instructions**: Your task is to respond to the expectant mother about whether or not she should vaccinate her child. To take a justified stance on the issue, search for information on the Internet that is as credible as possible.	---------
Specifying information need	What kind of information do you need in order to respond to the mother about whether or not she should vaccinate her child?	Sourcing in information need
Locating information	Search for three online texts that help you to provide credible information to the mother about whether or not she should vaccinate her child.	Sourcing in search queries
Identifying main ideas & evaluating information	What are the three most important ideas presented in the text that you can use in your response to the mother? What makes the source credible? What weakens the credibility of the source?	Sourcing in credibility judgements
Synthesizing and communicating information	What is your position on whether or not the expectant mother should vaccinate her child? (multiple choice item). Write below the justifications that support your position. Indicate sources that you rely on.	Sourcing in written products

Fig. 1. Task phases, task scenario, task prompts, and examined sourcing.

5.3. Online inquiry task

Fig. 1 presents the task scenario, task prompts, and flow of the task. The task scenario represents a fictitious situation where an expectant mother asks students to assist her in deciding whether or not to vaccinate her unborn child. To highlight the controversial nature of the task topic, we embedded two contradictory sources in the scenario, namely a civic organization's public lecture with a position against the vaccines and a nurse of the maternity clinic positioned for the vaccines. This was done to draw students' attention to the sources early on because it has been suggested that readers' attention to sources increases when different sources provide conflicting information about the issue [8,70].

In the task design, we relied on the Online Research and Comprehension model [48]. As shown in Fig. 1, the task flow followed the phases of online inquiry: specifying the information need and locating, evaluating, synthesizing and communicating information. In the first two phases (specifying the information need and locating information), sourcing was not explicitly prompted. In contrast, sourcing was explicitly prompted for evaluating the credibility of sources and composing the recommendation.

5.4. Task environment

Students conducted the task in a Web-based environment that was designed for research purposes. The task environment incorporated two existing tools, the Google Custom Search Engine and an online form builder called JotForm. Students used Google Custom Search Engine, composed of 35 pre-selected online texts, for locating information (see

Fig. 2). The JotForm included instructions for subtasks, task prompts, and spaces for students' responses (see Figs. 2 and 3).

The pre-selected online texts embedded in the Google Custom Search Engine were authentic. The texts were categorized by their usefulness to the task (see [52]): 1) More useful texts (texts with more relevance and higher source credibility), 2) Useful texts (texts with more relevance and lower source credibility AND texts with less relevance and higher source credibility), 3) Less useful texts (texts with less relevance and lower source credibility), and 4) Not useful texts (texts with no relevance and/or not credible).

The Google Custom Search Engine works like Google Search Engine, except that it only includes a limited number of information resources. Even though students were instructed only to use the information resources embedded in the Custom Search Engine, quite a few students selected one or two texts outside the Custom Search Engine, mostly as a result of clicking the hyperlinks in the pre-selected online texts. Altogether, students selected an additional 40 texts that were added to the textbase and categorized similarly as the preselected texts (see [34] for more details). Altogether there were 8 more useful texts (3 pre-selected and 5 other texts), 12 useful texts (5 and 8), 16 less useful texts (5 and 11) and 38 not useful texts (22 and 16). From all selections, 83% represented the pre-selected texts.

To support students' fluent working, the interface was split into two areas in some of the inquiry phases. For example, in the search phase, the Google Custom Search Engine appeared on the left-hand side, whereas the instructions and task prompts appeared on the right-hand side (Fig. 2). In addition, students were shown a progress bar and time
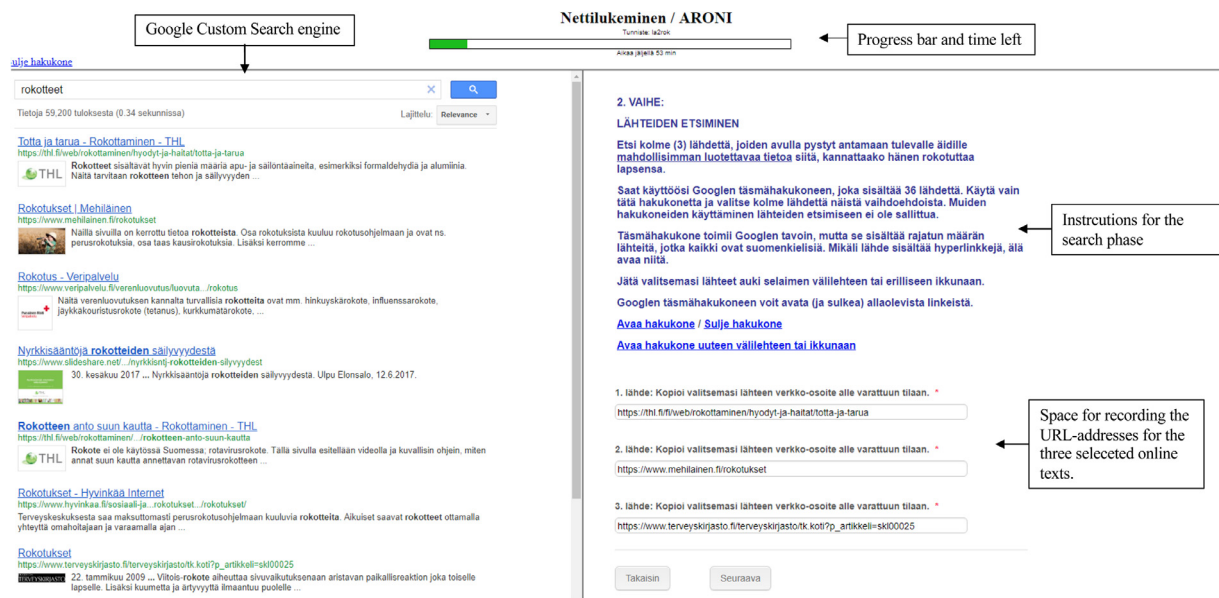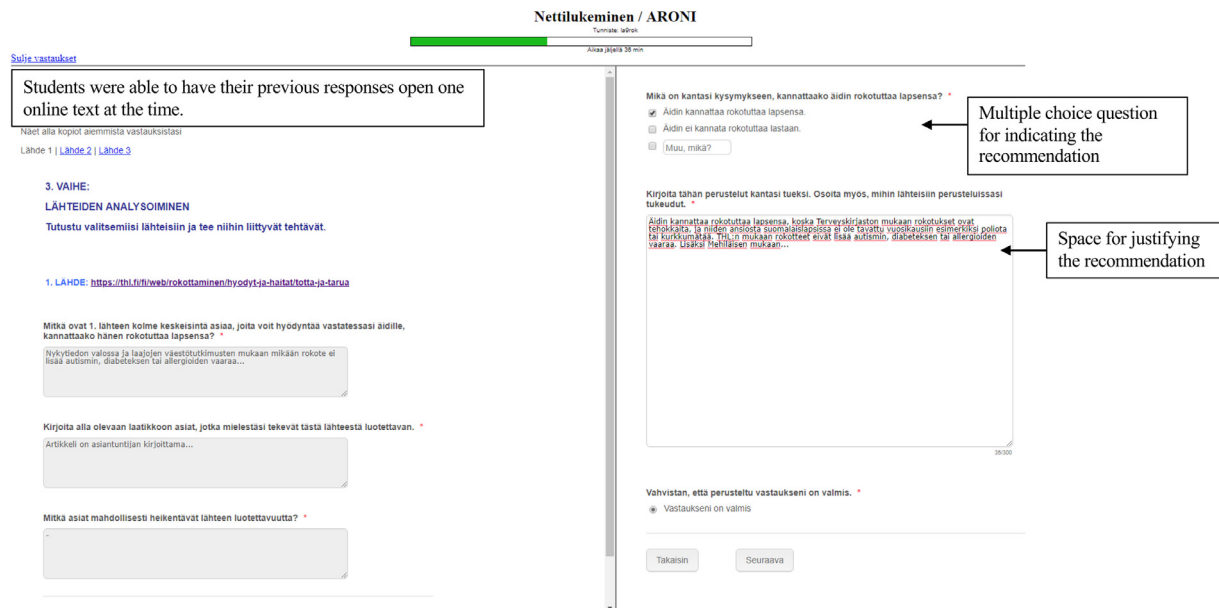
Fig. 2. Screenshot of the Search Phase.

Fig. 3. Screenshot of the Composition Phase.

left for the entire task at the top of each page. During the task, students were able to move between the task phases by using forward and backward buttons, but they could not revise the responses completed in the previous phase. After completing all task phases, students submitted their answers. Students' actions in the environment were recorded as a log file (including search queries and web pages visited), whereas students' responses were recorded in the JotForm service.

5.5. Procedure

The data was collected during a 75 min lesson in regular language arts classes by a researcher. All students completed the reading tasks, but only the data on students who gave informed consent were used. At the beginning of the lesson, students completed a reading fluency test. Then, students entered the task environment with a code given to them. Before the actual online inquiry task, students completed the

prior topic knowledge test. Students proceeded in their own space within a 60-minute time limit. If students encountered technical problems, a researcher helped in solving them.

5.6. Data analysis

Table 1 presents an overview of the four examined sourcing variables: sourcing in specifying the information need, sourcing in search queries, sourcing in credibility judgments, and sourcing in written products. The Kappa values presented in Table 1, were counted by having two independent rates to code 20% of students' responses. The disagreements were negotiated and solved. In the next sections, we will describe how we scored each variable.

5.6.1. Analysis of sourcing in specifying the information need

In the analysis of information need, we took into account specific named sources, source features (e.g., credentials, research, statistics)

Table 1

Sourcing Variables, Their Descriptions, Scoring, and Inter-Rater Reliabilities (Kappa Values).

Variable	Description	Score	Scoring	Kappa
Sourcing in specifying information need	The extent to which students refer to specific sources, source features, or present evaluative judgments when specifying information need.	0–3	Student's response included 1 point: one indication of sourcing i.e., a specific source, source feature, or evaluative judgment 2 points: two indications of sourcing 3 points: three or more indications of sourcing	.76
Sourcing in search queries	The extent to which students include specific sources or source features in their search queries.	0–3	Student's queries included 1 point: one specific source or source feature 2 points: two specific sources or source features 3 point: three or more specific sources or source features	.92
Sourcing in credibility judgments	The extent to which students attend to or evaluate author, author's motivation, or venue in their credibility judgments across three online texts.	0–9	In the credibility judgments of each online text student attended to / evaluated 1 point: one of the following author, author's motivation, or venue 2 points: two of the following author, author's motivation, and venue 3 points: author, author's motivation, and venue The total score was 3 online texts X 0–3 points	.75
Sourcing in written products	Whether students' written product is in line with the consensus among scientists and to what extend students written products include indications of sourcing (source-content links, source-source links, evaluative statements).	0–7	0 points: Student's written product (WP) is not in line with consensus among scientists.	

Student's WP is in line with consensus among scientists, AND:
1 point: Student does not mention any sources in his or her WP.
2 points: Student mentions specific sources or implicit sources in his or her WP.
3 points: Student's WP includes one or two indication of sourcing, i.e., source-content link, source-source link and/or evaluative statement.
4 points: Student's WP include three indications of sourcing
5 points: Student's WP includes at least four indications of sourcing
6 points: Student's WP includes at least five indications of sourcing that represent at least two categories: source-content link, source-source link and/or evaluative statement.
7 points: Student's WP includes at least five indications of sourcing that represent at all categories: source-content link, source-source link and/or evaluative statement. 0.78

and evaluative judgements about the credibility of information (e.g., references to a need for credible information or facts) in students' responses. Students were credited with 1 point when including one specific source, source feature, or evaluative judgment in their response, 2 points when including two, and 3 points when including three or more. Hence, the formed variable *Sourcing in Specifying the Information Need* ranged from 0 to 3 points. Example 1, below, illustrates a three-point response. The student first expresses the need for credible information and then mentions two potential sources (medical centers and Health and Welfare Institute). The student further explains that these sources rely on expert knowledge. The latter was considered an evaluative judgment.

Example 1.

I need reliable information to explain arisen issues. I think that online sources, such as medical centers or Health and Welfare Institute, are reliable because the information comes from experts (Student 1134).

5.6.2. Analysis of sourcing in search queries

The analysis of queries began with identifying the use of named sources or source features across all queries that students formulated during their information search. The following type of search terms were acknowledged: organizations (e.g., the Finnish Institute of Health and Welfare), names of persons relevant to the topic or credentials (e.g.,

doctor), and type of document (e.g., statistics, research). The number of different sources and source features was counted. If students included the same source feature in multiple queries, they were only credited once. Students were credited 1 point for one source or source feature, 2 points for two sources and/or source features, and 3 points for three or more sources and/or source features across their queries. The score for the variable *Sourcing in Search Queries* varied from 0 to 3.

5.6.3. Analysis of sourcing in credibility judgments

Analysis of students' sourcing in evaluations proceeded in two phases. In the first phase, students' responses were analyzed across both task questions (What issues make the source credible? and What issues may weaken the credibility?) by each selected online text. We examined whether students attended to and/or evaluated the following source features across the two responses: author (e.g., name, credentials, expertise), author's intention, and venue (publisher, service provider). Students were credited with one point for each. The authentic examples of the credited responses are provided in Table 2.

In the second phase, we formed a sum variable (3 online texts X 0–3 points/text). The correlations between the scores of three online texts were 0.20, 0.29, and 0.36, and they were statistically significant. The sum variable was named *Sourcing in Credibility Judgments* with a maximum score of 9.

Table 2
Examples of Credited Credibility Judgments.

	Credibility Judgment	
	Strengthening credibility	Weakening credibility
Source feature		
Author	The text has beenwritten by Hannu Jalanko, who is the doctor at the Helsinki University hospital. (Student 1069)	It is not on the website who has wrttien the text. (Student 1007)
Author's intention	Thl.fi is the website by the Finnish institue by health and welfare that investigates and follows public health and well-being. It also develops actions to promote them. (Student 1068)	The commercial goals of Mehiläinen and the need to sell one's services weakens the credibility. It could be that some information about a certain procut is dismissed to promote the sales. (Student 1080)
Venue	I think that the source is credible because Terveyskirjasto (Health Library) is a factual site where health experts have composed articles. I have been told that, for example, medical students use the texts in thier studies. (Student 1077)	Mehiläinen is a private health company. (Student 2026)

5.6.4. Analysis of sourcing in written products

The average length of the recommendations was 88.46 words ($SD = 57.82$). Because of the nature of the Finnish language, the recommendations in English would have included considerably more words.

The analysis of the recommendations began with the identification of sources that students mentioned in their written products. Students could refer to the selected online sources or information sources mentioned in the task assignment (civic organization, nurse/maternity clinic). Both explicit and implicit sourcing were marked (see [14,71]). In explicit sourcing, students include accurate source information of venue, author, or title of the online texts or URL address, whereas in implicit sourcing, students refer to the sources in a vague manner (e.g., referring to the "first source"). Students mostly engaged in explicit sourcing, and only this type of sourcing was acknowledged when counting the number of sources mentioned in the written products.

After having identified the sources students mentioned, we examined how they were used. Following the Documents Model framework [59], we examined how students used sources by identifying two types of links: source-content links and source-source links. Students were credited for a source-content link if the explicit source was connected to the statement presented in the text (e.g., "According to the Finnish Institute of Health and Welfare, vaccines do not cause autism."). Students were not credited with expressions such as "Go to X to find more information." Students were credited for a source-source link when they explicitly corroborated or contrasted statements presented by two sources. Example 2 illustrates a source-source link that questions the claim (vaccines weaken the resistance) presented in the task assignment by the civic organization with the contradictory information presented at the website of the Finnish Institute of Health and Welfare.

Example 2.

The claims presented in the public lecture organized by the civic organization do not hold up. The vaccines do not lower resistance, in contrast, they improve it. This information is presented on the website of the Finnish Institute of Health and Welfare [Student 1097].

Following Strømsø et al. [72], we also identified evaluative statements where students 1) evaluated the source of the text or sources mentioned in the task assignment, 2) referred to the credentials of the author or person interviewed or 3) highlighted the research-basis of the source. In Example 3, the student evaluates the publication venues by stating that information presented on the websites was provided by experts.

Example 3.

I found the information above from the official websites of Mehiläinen, the Finnish Institute of Health and Welfare and Chemistry magazine, where only experts and highly educated people can write [Student 1062].

Finally, on the basis of analyses described above, we scored students' written products by applying the scoring system presented in Table 1. The variable was labelled as *Sourcing in Written Products*.

5.7. Statistical analysis

To examine how sourcing in the earlier phases of inquiry contributes to sourcing in the latter phases, we conducted two sequential regression analyses [73]. With the first regression analysis, we examined how sourcing in the information need and in search queries (independent variables) were associated with sourcing in credibility judgments (dependent variable). With the second regression analysis, we examined how sourcing in information need, search queries, and credibility judgments (independent variables) were associated with sourcing in written products (dependent variable).

As shown in Table 2, there were some missing data in two of the sourcing variables: sourcing in the information need and sourcing in search queries. Nine students responded to the final task instead of to the information need task. Seven students did not use Google Custom Search. Because they did their searchers outside of our task environment, their search queries were not recorded into the log files. Because we were examining sourcing throughout online inquiry, we excluded from analysis those students who did not successfully complete all phases of the online inquiry task. Thus, the missing data described here were excluded listwise. Given that Little's test [50] indicated that the missingness in the data was completely random ($\chi^2(19) = 25.26$, $p = .152$), we concluded that the missing data had no effect on the outcomes

6. Results

Table 3 presents descriptive results for the studied variables. As shown, sourcing in search queries was rare, whereas students more frequently engaged in sourcing when specifying their information need. Two-thirds of the students mentioned online sources in their written product, whereas very few referred to the sources mentioned in the task assignment. When it comes to the use of sources in the written products, half of the students included source-content links, and a little less than a third of the students presented evaluative statements in their written products. In contrast, students rarely included source-source links in their written products. Table 4 shows the correlations between studied variables.

Table 5 presents the results of the sequential regression analysis predicting sourcing in credibility judgments. The full model was statistically significant ($F(4, 147) = 7.55$, $p < .001$) explaining 17% of variance between students' sourcing in credibility judgments. Prior topic knowledge and reading fluency (entered in step 1) were not statistically significant predictors for sourcing in credibility judgments ($F(2, 149) = 2.08$;

Table 3

Descriptive Statistics.

Variable (observed range)	N	M	SD	Skewness	Kurtosis	% of students who engaged in sourcing
Reading fluency (32–100)[a]	166	72.53	15.88	−0.10	−0.57	Na.
Prior knowledge (0–6)[a]	167	4.02	1.33	−0.17	−0.32	Na.
Sourcing in information need (0–3)[a]	158[b]	1.13	1.00	0.42	−0.94	67.1
Sourcing in search queries (0–3)[a]	160[c]	0.46	0.78	1.77	2.50	31.2
Sourcing in credibility judgments (0–7)[a]	167	3.46	1.55	0.22	−0.35	98.2
Number of online sources mentioned in written products (0–3)	167	1.38	1.17	0.07	−1.49	65.9
Number of sources in task assignment mentioned in written products (0–2)	167	0.23	0.56	2.37	4.43	16.2
Total number of sources mentioned in written products (0–5)	167	1.60	1.37	0.29	−0.84	67.7
Source-content links in written products (0–10)	167	1.39	1.83	1.69	3.81	50.9
Source-source links in written products (0–2)	167	0.11	0.37	3.46	12.13	9.6
Evaluative statements in written products (0–3)	167	0.46	0.77	1.85	3.14	31.7
Sourcing in written products (0–7)[a]	167	3.00	1.84	0.47	−0.72	Na.

Note.

[a] variables used in the statistical analysis.

[b] students, whose response concern information need.

[c] student who did their search in the Google Custom Search Engine and the log files were recorded.

Table 4

Correlations Between Variables ($N = 158$–167).

Variable	1	2	3	4	5
1. Reading fluency					
2. Prior topic knowledge	.011				
3. Sourcing in information need	−.101	−.033			
4. Sourcing in search queries[a]	.130	−.005	.068		
5. Sourcing in credibility judgments	.172*	.039	.181*	.256**	
6. Sourcing in written products	.223**	.153*	−.017	.184*[a]	.360***

Note. [a] = Spearman correlation coefficient;.

* $p < .05$;.

** $p < .01$;.

*** $p < .001$.

Table 5

Results of Sequential Regression Analysis for Variables Predicting Sourcing in Credibility Judgments ($N = 152$).

Variable	β	p	R^2	ΔR^2
Step 1			.03	
Prior topic knowledge	.06	ns.		
Reading fluency	.15	ns.		
Step 2			.17***	.14***
Prior topic knowledge	.06	ns.		
Reading fluency	.14	ns.		
Sourcing in information need	.19	.012		
Sourcing in search queries	.32	< .001		

Note.

*** $p < .001$.

Table 6

Results of Sequential Regression Analysis for Variables Predicting Sourcing in Written Products ($N = 152$).

Variable	β	p	R^2	ΔR^2
Step 1			.09**	
Prior topic knowledge	.19	.017		
Reading fluency	.23	.004		
Step 2			.18**:*	
Prior topic knowledge	.17	.027		
Reading fluency	.17	.030		
Sourcing in information need	−.04	ns.		
Sourcing in search queries	.08	ns.		
Sourcing in credibility judgments	.27	.001		

Note.

** $p < .01$;.

*** $p < .001$.

$p = .129$). In Step 2, we included sourcing in specifying the information need and sourcing in search queries into the model. As expected, both sourcing in the information need and sourcing in search queries were statistically significant predictors for students' sourcing in credibility judgments, resulting in a statistically significant 14% increment in the explained variance ($F_{Change}(2, 147) = 12.70$; $p < .001$). Thus, the more actively students engaged in sourcing when specifying the information need and formulating search queries, the more actively they also engaged in sourcing when judging the credibility of online texts.

Table 6 presents the results of the sequential regression analysis predicting sourcing in written products. The full model was statistically significant ($F (5, 146) = 6.34, p < .001$) explaining 18% of variance between students' sourcing in written products. At step 1, prior topic knowledge and reading fluency predicted statistically significantly sourcing in written products, explaining 9% of the variance ($F(2, 149) = 7.25$; $p = .001$). In Step 2, we included three sourcing variables (sourcing in specifying the information need, sourcing in search querying, and sourcing in

credibility judgments) into the model that resulted in a statistically significant 9% increment in the explained variance ($F_{Change}(3, 146) = 5.32$; $p = .002$). Sourcing in credibility judgments was the only statistically significant predictor in addition to the control variables: the more actively students engaged in sourcing in judging the credibility of online texts, the more active and diverse was their sourcing in the written products.

7. Discussion

This study is the first to investigate students' engagement in sourcing throughout online inquiry, that is, how students attend to, discern, apply, evaluate, and represent sources during different phases of online inquiry. Observations of students' sourcing in different phases of online inquiry allowed us to also examine the relations among sourcing activities across the online inquiry phases.

7.1. Sourcing appears across all phases of online inquiry

The results show that students engage in sourcing even in the earliest phases of online inquiry. About two-thirds of the students engaged in sourcing, that is, activating their prior source knowledge when specifying the information need. They either thought about specific sources (e.g., organizations) or source features (e.g., profession, type of information), or expressed evaluative judgments to set criteria for the quality of information. Sourcing in search queries was not as common compared to sourcing when specifying the information need. A little less than one-third of the students used sources or source features in their queries. This is a reasonable finding, since novice readers are not particularly skillful in restricting their search queries (see, for example, 27, [55]).

When prompted to judge online texts, almost all students attended to sources or evaluated their credibility at least once. Students were credited one point for each unique aspect (author, intentions, venue) that they attended to or evaluated across three online texts with a mean score of 3.5 out of 9 points. This suggests that students' sourcing during credibility judgments was not that versatile. This is in line with previous research showing that many students evaluate online information rather superficially [26,54]. Likewise, there were considerable differences in students' sourcing when judging credibility of online texts, as also shown in previous studies [31,42].

Even though students were prompted to indicate their sources in their written products, almost one-third of them did not include any explicit sources in their recommendations. In addition, only half connected the sources to the statements presented by the source, at least once. Very few students included source-source links in their written products, meaning that they did not explicitly compare or contrast sources' views. These findings are in line with previous research showing that students in various educational levels struggle with sourcing in their writing [41,58,63].

7.2. Associations among sourcing during different phases of online inquiry

As expected, sourcing in the information need and sourcing in search queries were positively associated with sourcing in credibility judgments. Thus, the more actively students engaged in sourcing in the earliest phases of online inquiry, the more active (i.e., frequent and diverse), was their engagement in sourcing when judging the credibility of online texts. This result could be interpreted in a way that students with a critical mindset integrate the idea of high-quality sources into their task model and attend to sources when specifying their information need, or use their source knowledge when formulating search queries. The activated source knowledge, in turn, facilitates sourcing when judging the credibility of online texts. In the present study, however, students were asked to find credible sources and evaluate the selected online texts. It remains for future studies to examine whether these relations are still present when students engage in spontaneous online inquiry. It should be noted that our correlation analysis showed (Table 3) that sourcing in specifying the information need and sourcing in search queries were not associated with each other. One possible explanation for this finding is that students need sophisticated search strategies to restrict their queries to be able to take advantage of source knowledge activated prior to locating information.

We expected that all sourcing activities prior to synthesizing and communicating one's findings in a written product would be related to sourcing in the written products. This expectation was only partly confirmed, however, as sourcing in credibility judgments was the only activity that was related to sourcing in the written products. This is in line with previous findings of a positive relationship between sourcing in evaluation of credibility and written products [2,4,72]. Because sourcing in specifying the information need and in search queries was related to sourcing in credibility judgments, it might well be that the former types of sourcing facilitate sourcing in written products through sourcing when judging the credibility of online texts. Future research

could examine these possible mechanisms among more competent readers, such as university students or experts.

Even though the role of reading fluency and prior knowledge in sourcing was only included in the analysis as control variables, we would like to note an interesting observation around prior knowledge. We found a positive relationship between prior topic knowledge and sourcing in written products but not between prior topic knowledge and sourcing in credibility judgments. One possible explanation could be that when attending to and evaluating sources, students benefit more from prior source knowledge than from prior topic knowledge. This may be because, in a multiple text activity, students can develop topic knowledge as they read [23]. Future research should consider both of these types of prior knowledge to more fully understand the facilitating role of prior knowledge in sourcing throughout online inquiry.

7.3. Limitations

This study has three limitations that are worth noting. First, the online inquiry task was sequenced into phases that students completed in a pre-determined order. Students were not allowed to change their responses after completing a particular phase. Thus, we were not able to fully examine students' online inquiry as an iterative process where students may go back and forth between the inquiry phases. For example, we do not know whether students updated their representation of the information need during online inquiry (see also [27]).

Second, there was some variation in how explicitly students were prompted to source in the different task phases. This might have been reflected in how actively students engaged in sourcing. For example, previous studies have shown that students seldom spend time on specifying their information need [6,27]. We decided to prompt students' sourcing, while previous research suggests that students do not always engage in sourcing even if they have the knowledge and strategies to do so [57] This allowed us to examine students' sourcing.

Finally, in the search phase, some students visited online texts that were not included in the Google Custom Search Engine, and we did not have any log data on the activities (e.g., search queries) outside of our task environment. The other selected texts counted for 17% of all text selections. However, we included these texts in our textbase and categorized them similarly as the pre-selected texts.

7.4. Theoretical and instructional implications

There are several theoretical and instructional implications that can be drawn from our findings. One theoretical contribution relates to our findings suggesting that sourcing occurs throughout all online inquiry phases, which in turn may have implications for the theoretical models that guided our work. First, the Online Research and Comprehension model does argue that evaluation of information, including sourcing, appears iteratively throughout online inquiry [48]. However, the model does not explicate how this occurs. Because our study suggests that sourcing is one core process in online inquiry, there is a need to update the model to better acknowledge the role of sourcing throughout online inquiry. Second, it may well be that building an intertext model [59] may begin early on when readers engage in online inquiry. When readers specify their information need and formulate search queries, they may well think of potential sources and source features that may facilitate the evaluation of sources and the development of a coherent representation across texts. Because our study provided some signals of this, even among adolescent readers, it may be worth investigating how thinking of potential sources is reflected in building of the intertext model among expert readers.

From an instructional point of view, our results suggest that students would benefit from instruction emphasizing that sourcing is not a one-time activity but a continuous process that readers engage in throughout the different phases of online inquiry. Thus, instruction could provide both declarative and procedural knowledge about sourcing in different

online inquiry phases. Importantly, to understand how sourcing activities influence each other, students also need guidance on how to take a holistic perspective of the entire inquiry process. In particular, students who have not been previously active in sourcing would benefit from models of effective sourcing practices [24] followed by practice and discussions with their peers [35]. Further, students should be taught why sourcing is a crucial part of online inquiry [57] and how sourcing activities in the earliest phases of inquiry serve sourcing in latter phases.

Next, we will give a few examples of how these ideas could be put into practice. Before turning to a search engine, teachers can ask students to consider what kinds of sources are needed in a particular task, and what could be potential sources or task-relevant source features. Then, teachers can model how students can use this activated source knowledge in the formulation of search queries. Students with low prior source knowledge could be shown how to evolve their queries with retrieved search results. Thus, even if readers do not have relevant source knowledge in the beginning of the inquiry, they might update their knowledge about task-relevant sources or source features in the course of locating information. With this updated knowledge, readers can evolve their queries to locate online texts that may help them to broaden their view on the topic. For example, students can pay attention to who is talking about the issue (experts in a particular field, researchers, policymakers) and in what types of documents and venues (news, organizations). Students can then use these observations when formulating additional queries themselves.

Notably, it should be discussed with students that restricting queries with potential sources or source features is only one search strategy among others. Since some students are looking for a single recipe to follow, it should be emphasized that like any other search strategy, it may be useful in some situations but not in others. For example, it may be particularly helpful in situations where students have difficulties finding trustworthy information.

After opening promising websites, students can be asked to think of how their initial ideas about sources are realized in the selected websites. Students can be shown how activated source knowledge facilitates the evaluation of sources: students already have an idea of what to look for. When evaluating credibility of sources it is important to discuss with students why sources should be evaluated from multiple perspectives [29]. Finally, source evaluations are valuable when students compose a written product as students can communicate in-depth information about their sources. Source evaluations also facilitate comparing and contrasting different sources and their views – the depth of thinking that all teachers are hoping their students can learn to demonstrate.

8. Conclusion

While prior work has looked at sourcing during one or two inquiry phases, the current study examined the role of sourcing throughout an inquiry task. Rather than conceptualizing sourcing as something readers do at a certain point in the inquiry process, the current study suggests that sourcing is actually a set of practices that are used in an iterative fashion and in different ways throughout the entire inquiry process, thus guiding readers' engagement in the other phases of inquiry. Further research is needed to fine tune our understanding of what these sourcing practices are and how readers use them iteratively. However, such sourcing practices might include activities such as activating prior knowledge about potential sources and source features, and attending to, representing, evaluating, and applying source features. Thus, much as Wineburg and Reisman [80] describe sourcing not as a strategy but as "an entire way of apprehending the world" (p. 636), the present study suggests that sourcing may be a habit of mind with which readers engage in the entire inquiry process, supporting more critical and nuanced interpretations of online texts .

Declaration of Competing Interest

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