Epistemic Thinking in Action: Evaluating and Integrating Online Sources

2 authors:

Sarit Barzilai
University of Haifa
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Anat Zohar
Hebrew University of Jerusalem
57 PUBLICATIONS   **1,976** CITATIONS

Epistemic Thinking in Action: Evaluating and Integrating Online Sources

Sarit Barzilai and Anat Zohar

Hebrew University of Jerusalem

This study examines epistemic thinking in action in order to shed light on the relation between students' personal epistemologies and their online learning practices. The study is based on observations of the learning behaviors of 6th-grade students ($n = 38$) during two online inquiry tasks. Data were collected through think-aloud protocols and retrospective epistemic interviews. The study examines how absolutist and evaluativist epistemic perspectives come into play in two key online inquiry strategies—evaluation of website trustworthiness and critical integration of multiple online sources. The study explores students' epistemic thinking on the cognitive and metacognitive levels and examines epistemic metacognitive knowledge about both persons and strategies. The findings demonstrate that epistemic thinking plays an important role in online inquiry learning. Participants' epistemic metacognitive knowledge regarding online learning strategies correlated with their epistemic cognition. Evaluativists significantly outperformed absolutists in the integration strategy but no significant differences were found in the evaluation strategy. Furthermore, there was evidence for considerable variability in students' epistemic thinking. The complex role of students' epistemic thinking in online learning is analyzed and discussed.

The study of personal epistemology, of how people think about knowledge and knowing, has developed rapidly in the past decade. Although multiple studies show that personal epistemology is related to learning practices and student achievement (e.g., Bråten, Britt, Strømsø, & Rouet, 2011; Hofer, 2001; Mason & Scirica, 2006; Trautwein & Lüdtke, 2007a; Weinstock, Neuman, & Glassner, 2006), relatively little is known about the role of personal epistemology in learning processes. How do personal ideas about knowledge and knowing come into play in the course of learning? And how might epistemic development shape, or be shaped by, learning experiences in context? Investigating these questions requires a close observation of students' epistemic thinking during the course of learning.

This study focuses specifically on Web-based inquiry learning using authentic online sources. Web-based learning has become a standard feature in many schools, alongside traditional textbooks and workbooks (National Center for Educational Statistics, 2006). However, the epistemic characteristics of the knowledge found on the Internet have the potential to be radically different from those of the knowledge usually presented by teachers and schoolbooks (Dede, 2008). Instead

of a single coherent account, Internet search results often include multiple accounts that differ in scope, argument, and support. Furthermore, online sources may vary widely in their authorship, purpose, perspective, credibility, and modes of justification. These epistemic characteristics present a challenge to students' epistemologies. The present study seeks to understand students' response to that challenge and the role of their epistemic thinking in online learning processes. We focus on two strategies[1] that are important for effective online inquiry—evaluation of website trustworthiness and critical integration of multiple online sources.

Our conceptualization of epistemic thinking is based on Kuhn and Weinstock's view of personal epistemology as a "theory-in-action" (2002, p. 134). The "theory" part of this view relates to the personal theories or perspectives that individuals have about knowledge and knowing. Kuhn and colleagues suggest that these theories develop with age and experience as students grapple with the challenge of coordinating the objective and subjective dimensions of knowing (Kuhn, 1991, 2001; Kuhn, Cheney, & Weinstock, 2000; Kuhn & Weinstock, 2002). The "in action" part refers to the view that these theories come into play in the course of everyday knowledge judgments and knowledge construction. They inform the ways in which we approach tasks but are also activated in and shaped by contexts, for example, by the nature of different domains of judgment (Kuhn et al., 2000), by cultural intellectual values (Kuhn & Park, 2005), and by task conditions (Kuhn, Iordanou, Pease, & Wirkala, 2008).

In this study we observe epistemic thinking in the contexts of two online inquiry tasks. Examining students' epistemic thinking in practice sheds light on students' "practical epistemologies" (Sandoval, 2005). Sandoval defines practical epistemologies as "the epistemological ideas that students apply to their own scientific knowledge building through inquiry" (p. 635). He goes on to argue that understanding students' practical epistemologies may enable us to understand the links between students' epistemic beliefs and their inquiry practices. In order to gain insight into students' practical epistemologies, this study focuses on online inquiry strategies as the main unit of analysis rather than on students' epistemic thinking according to general epistemic dimensions, as was done in previous studies on epistemic thinking during online learning (Hofer, 2004; Mason & Boldrin, 2008; Mason, Boldrin, & Ariasi, 2010a, 2010b). The focus on inquiry strategies helps advance the understanding of students' practical epistemologies by revealing their epistemic thinking concerning specific strategies used during online learning.

THEORETICAL FRAMEWORK

The field of personal epistemology and the debates that characterize it have been reviewed extensively (Bendixen & Rule, 2004; Buehl & Alexander, 2001; Greene, Azevedo, & Torney-Purta, 2008; Hofer & Pintrich, 1997; Limón, 2006). In the following sections we present and discuss several issues central to our exploration of epistemic thinking in the course of online learning: views regarding the construct of personal epistemology, the issue of contextuality and variability in epistemic thinking, the complex relationship between personal epistemology and metacognition, and the role of epistemic thinking in Web-based learning.

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[1]The term "strategies" is used to denote cognitive actions or behaviors employed to achieve task goals (Flavell, 1979). For example, the evaluation of website trustworthiness strategy refers to the actions used to establish the credibility of online sources.

To refer to the field as a whole, we use the term *personal epistemology*, the term most often used in the literature (Greene et al., 2008; Hofer & Pintrich, 2002). When discussing theories of specific researchers, we employ the same terminology used by the researcher. In our study, we prefer to use the term *epistemic thinking* as a general term encompassing both *epistemic cognition* and *epistemic metacognition.* Finally, we describe students' thinking about knowledge and knowing as *epistemic* rather than *epistemological* since, as R. Kitchener (2002) pointed out, the term *epistemological* relates to the study of epistemology.

The Construct of Personal Epistemology

The field of personal epistemology lacks a single theoretical and methodological framework agreed on by researchers in the field (Bendixen & Rule, 2004; Hofer & Pintrich, 1997). Although the differences between the various approaches are considerable, researchers share the view that people's beliefs and theories regarding knowledge and knowing play an important role in formal and informal learning. Another point of general agreement is that personal epistemology can and does develop with age and experience (for additional points of agreement and dissenting voices, see Pintrich, 2002a). There are three major competing theoretical perspectives that offer different models of personal epistemology: developmental perspectives, beliefs perspectives, and the resources perspective. Developmental models of personal epistemology generally view students as holding integrated epistemic positions or perspectives (Baxter Magolda, 2002; Belenky, Clinchy, Goldberger, & Tarule, 1986; King & Kitchener, 2002; K. S. Kitchener, 1983; Kuhn et al., 2000; Kuhn & Weinstock, 2002). These models see students' epistemic perspectives as developing throughout the course of life and study, often following a typical trajectory (for discussions of developmental approaches to personal epistemology, see Chandler, Hallett, & Sokol, 2002; Greene et al., 2008; Hofer & Pintrich, 1997; Limón, 2006; Pintrich, 2002a). Whereas developmental perspectives emphasize the interrelatedness of the various dimensions of individuals' epistemic thinking, the beliefs approach to the study of personal epistemology, an approach originating in the work of Schommer (Schommer-Aikins, 2002, 2004; Schommer, 1990), contends that epistemic beliefs (for example, regarding the complexity or certainty of knowledge) do not necessarily develop synchronously and that students' personal epistemologies are multidimensional (for a review of studies see Buehl, 2008). A third, and substantially different, approach is the epistemological resources approach proposed by Hammer, Elby, and colleagues (Elby & Hammer, 2001, 2010; Hammer & Elby, 2002; Louca, Elby, Hammer, & Kagey, 2004). Epistemological resources are knowledge and ideas people use in order to understand and reflect on their epistemic knowledge, activities, forms, and stances. Elby, Hammer and colleagues view epistemological resources as fine-grained cognitive resources that are activated by context according to a local epistemological frame (Elby & Hammer, 2010).

In this research we adopt the developmental model proposed by Kuhn and colleagues (Kuhn, 1991, 1999, 2001; Kuhn et al., 2000, 2008; Kuhn & Weinstock, 2002; Weinstock, 2009; Weinstock & Cronin, 2003). Kuhn's model describes the underlying task driving the development of epistemological understanding as the coordination of the objective and subjective dimensions of knowing. The developmental trajectory outlined in this model revolves around a shift from an *absolutist* view that knowledge is objective, located in the external world, and certain, to a *multiplist* view according to which the source of knowledge is the individual and

knowledge is therefore multiple, subjective, uncertain, and cannot be adjudicated. The further shift to an *evaluativist* view is driven by the need to coordinate and balance between the subjective and objective dimensions of knowledge. The evaluativist considers knowledge as constructed and acknowledges uncertainty without forsaking the need for evaluation (Kuhn et al., 2000; Kuhn & Weinstock, 2002).

Epistemic Thinking in Context

Studies of personal epistemology have repeatedly documented considerable variability in students' epistemic thinking both across and within contexts. Variability in epistemic thinking has been observed across discipline domains such as science or history (e.g., Hofer, 2000; Muis, Bendixen, & Haerle, 2006), judgment domains such as taste, morals, or truths (e.g., Kuhn et al., 2000; Mason, Boldrin, & Zurlo, 2006), or tasks in the same domain (e.g., Kuhn et al., 2008; Weinstock, 2011). These observations raise the need to account for the role of context in epistemic thinking and for the mechanisms that shape students' behavior across contexts.

Researchers of personal epistemology construe the role of context in substantially different ways. Researchers from the resources perspective examine students' personal epistemologies in highly localized and dynamic contexts. From the resources perspective, variability is the rule rather than the exception since different contexts activate different resources or frames (Elby & Hammer, 2010; Hammer & Elby, 2002). Elby and Hammer (2001) suggest that a sophisticated epistemology entails context-sensitive judgments. Thus they point out that it is not very sophisticated to view the idea that the earth is round rather than flat as "tentative," whereas theories of dinosaur extinction do require a more tentative stance.

Researchers who adopt the beliefs perspective have examined epistemological beliefs in the context of academic disciplines, such as physics or history (e.g., Buehl & Alexander, 2002; Hofer, 2000; Stahl & Bromme, 2007) and, more recently, in topic-specific contexts, such as climate change (e.g., Strømsø, Bråten, & Samuelstuen, 2008; Trautwein & Lüdtke, 2007b). Recent models of epistemological beliefs suggest that individuals simultaneously possess and activate both general and domain-specific epistemological beliefs and that there is reciprocal interaction between domain-general and domain-specific beliefs (see models proposed by Buehl & Alexander, 2002; Muis et al., 2006). Bromme and colleagues, following Elby and Hammer, suggest that sophisticated personal epistemology is marked by the ability to adapt epistemic behavior flexibly to the relevant context (Bromme, Kienhues, & Stahl, 2008; Bromme, Pieschl, & Stahl, 2010).

Developmental researchers examine individuals' personal epistemologies through contextual measures that relate to specific scenarios or dilemmas but also suggest that there is an underlying developmental trajectory explaining development across contexts. For example, Kuhn and colleagues propose that the development of epistemological understanding, while following the same general sequence, varies across judgment domains (Kuhn et al., 2000; Kuhn & Weinstock, 2002) as well as between tasks (Kuhn et al., 2008; Kuhn & Pearsall, 2000; Kuhn & Weinstock, 2002; Weinstock, 2011). However, Kuhn and her colleagues note that:

> This specificity of content and context by no means dictates a retreat to radical domain-specificity. To the contrary, a common developmental progression can be identified, with a number of different and more specific challenges that may be encountered along the way. Different problem content and contexts emphasize these challenges to a greater or lesser extent. (Kuhn et al., 2008, p. 447)

This study adopts the view that personal epistemology has both general and context-specific aspects and, therefore, examines students' epistemic perspectives while also paying attention to the role of strategy and task contexts (Buehl & Alexander, 2002; Kuhn et al., 2008; Kuhn & Weinstock, 2002; Muis et al., 2006). In our examination of context, we adopt the proposition that sophisticated epistemic thinking is marked by the ability to make context-sensitive judgments and that variability in students' personal epistemology can be interpreted as a sign of adaptivity to context (Bromme et al., 2008, 2010; Elby & Hammer, 2001).

Metacognitive and Cognitive Aspects of Epistemic Thinking

Metacognition is generally defined as knowledge about cognition and as regulation and control of cognitive activities (Brown, 1978; Flavell, 1979). The distinction between metacognitive knowledge and metacognitive skills is one of the most basic distinctions drawn in the literature (Pintrich, 2002b; Veenman, Van Hout-Wolters, & Afflerbach, 2006). *Metacognitive skills* include processes of regulation and control of cognition, such as monitoring, evaluation, recapitulation, and reflection (Brown, 1978; Flavell, 1979; Schraw & Moshman, 1995; Veenman, 2005). *Metacognitive knowledge* is frequently defined, following Flavell (1979), as the individual's knowledge about person, task, and strategy variables that affect cognitive performance (Flavell, Miller, & Miller, 2002; Pintrich, 2002b; Veenman et al., 2006). *Knowledge of persons* refers to self-knowledge of the variables that influence the individual's cognitive activity, knowledge of the cognition of others, and knowledge of the universals of people's cognition. *Knowledge of tasks* refers to understanding how the nature of task conditions, demands, and goals affects cognitive activity. *Knowledge of strategies* refers to knowledge about thinking, learning, and problem-solving strategies that students might use to achieve goals. Kuhn views strategy and task knowledge as interrelated sub-components of *metastrategic knowledge*. Metastrategic knowledge, as defined by Kuhn, entails knowledge about what thinking strategies can accomplish; about when, why, and how to use these strategies; and about the goals and requirements of tasks (Kuhn, 1999; Kuhn & Pearsall, 1998). Studies have shown that metastrategic knowledge is a key aspect of metacognition and contributes significantly to the development of strategic competence (Kuhn & Pearsall, 1998; White & Frederiksen, 1998; Zohar & Ben David, 2008; Zohar & Peled, 2007).

Several researchers have pointed out that epistemic thinking operates at the metacognitive level. Kitchener (1983) described a three-level model of *cognition*, *metacognition*, and e*pistemic cognition*. Although Kitchener distinguishes between metacognition and epistemic cognition, she essentially views epistemic cognition as operating at a "meta-meta" level. Epistemic cognition, according to Kitchener, monitors the cognitive and metacognitive aspects concerned with assumptions about knowledge and knowing. Kuhn (1999, 2001) sees *epistemological meta-knowing* as a component of meta-knowing that relates to abstract knowing about knowledge and knowing in general. Epistemological meta-knowing is concerned, according to Kuhn, with how individuals conceptualize knowledge and knowing as they engage in cognitive tasks. Whereas Kuhn describes epistemological meta-knowing as a type of metacognitive knowledge, Hofer (2004) expands the definition of e*pistemic metacognition* to include both metacognitive knowledge and metacognitive skills of regulation and control of cognition.

Epistemic thinking has a strong metacognitive aspect, but it is not restricted to the metacognitive level. Recently, Hofer (2005) has suggested that personal epistemology operates both

cognitively and metacognitively. Calls for such a distinction between the cognitive and metacognitive aspects of epistemic thinking have also appeared elsewhere. For example, in a recent article, Richter and Schmid (2010) suggest a distinction between *epistemic strategies* and *epistemological metacognition.* They propose that epistemological metacognition is related to students' use of epistemic strategies.

In the current study, we also distinguish between students' epistemic cognition and their epistemic metacognition. We define epistemic cognition as thinking that relates to the epistemic characteristics of specific information or sources in context (e.g., "Is this particular statement correct?" "Is this particular website biased?"). In such cases, the *object-level* of thinking is not the general or abstract nature of knowledge or knowing but, rather, the epistemic characteristics of particular knowledge items. For example, when students evaluate the credibility of a certain website or attempt to integrate and reconcile specific competing claims, they engage in epistemic cognitive level strategies.

By contrast, if the object of thinking is the nature of personal knowledge and knowing, other persons' knowledge and knowing, and knowledge and knowing in general, then the thinking is defined as metacognitive. With regard to the metacognitive domain, we adopt Hofer's (2004) view of epistemic metacognition as multifaceted. Studies in the field of personal epistemology have often focused on a specific aspect of epistemic metacognition—students' epistemic metacognitive knowledge (EMK) about the nature of **persons'** knowledge and knowing. In our view, it is necessary to expand the examination of EMK in order to account for knowledge about the epistemic nature of **strategies** and **tasks** (Flavell, 1979; Kuhn, 1999; Kuhn & Pearsall, 1998; Pintrich, 2002b). In the present study, we therefore examine two aspects of students' EMK: (a) epistemic metacognitive knowledge about persons (EMKP), and (b) epistemic metacognitive knowledge about strategies and tasks (EMKS). EMKP includes meta-knowledge about the individual as knower (e.g., that I am sometimes uncertain about the trustworthiness of what I read online), about other people as knowers (e.g., that X is an expert about topic A but is not very knowledgeable about topic B), and about human knowledge in general (e.g., that websites may differ widely in their sources, perspectives, and means of justification). EMKS includes meta-knowledge about how to carry out an activity that will result in knowing (e.g., knowledge about when, why, and how to corroborate websites by seeking out multiple websites and comparing their sources and claims), and knowledge about the epistemic nature of tasks (e.g., which tasks may be accomplished with the help a single website and which tasks require more extensive searching and integration). We view the meta-persons (EMKP) and meta-strategic (EMKS) components of EMK as interrelated and interactive facets of individuals' epistemic metacognition (Flavell, 1979). Finally, it is important to note that the type of metacognitive knowledge we are considering in this study is explicit knowledge that can be stated and reported (Jacobs & Paris, 1987). We see the ability to reflectively access and describe metacognitive knowledge as one of the indicators of students' understanding (Brown, 1987).

Personal Epistemology and Web-Based Learning

The Internet fundamentally changes how information is accessed, organized, and used. The abundance, variety, and accessibility of online information require enhanced critical thinking and the development of individual information skills (American Association of School Libraries, 2007).

The importance of the Internet as a source of information has led researchers in recent years to examine the relationship between personal epistemology and online learning (e.g., Bråten, Strømsø, & Samuelstuen, 2005; Hartley & Bendixen, 2001; Hofer, 2004; Kienhues, Stadtler, & Bromme, 2011; Mason & Boldrin, 2008; Mason et al., 2010a, 2010b; Pieschl, Stahl, & Bromme, 2008; Strømsø & Bråten, 2010; Tsai, 2004). Hofer (2004) and Mason and colleagues (Mason, Ariasi, & Boldrin, 2011; Mason & Boldrin, 2008; Mason et al., 2010a, 2010b) have studied students' epistemic beliefs in the course of online learning by using think-aloud protocols. Their studies reveal that epistemic beliefs are activated at multiple points during online learning as students monitor and judge online information. Hofer (2004) proposed that if students perceive knowledge as simple and certain, searching may be brief and perfunctory, and they may find it unnecessary to search for additional websites in order to integrate information or to deliberate about the credibility of the online sources. Mason and colleagues have found relations between patterns of epistemic metacognition and Web-based learning. For example, students with sophisticated views concerning the justification of online knowledge by comparison of multiple sources and use of scientific evidence had higher gains from online learning (Mason et al., 2010a).

Tsai (2004) hypothesized that the Internet is an epistemic tool with a dual role: On the one hand, advanced epistemological beliefs may facilitate the use of the Internet for learning; on the other, Internet-based instruction may help change or reshape students' epistemologies. Studies have found initial evidence for both claims. For example, Tsai and colleagues have demonstrated that eighth graders with more advanced epistemological beliefs have better search outcomes in open-ended online tasks (Tu, Shih, & Tsai, 2008), and Bråten and Strømsø have shown that Internet-specific epistemological beliefs predict online learning behavior such as searching and help-seeking (Bråten et al., 2005; Strømsø & Bråten, 2010). From the other direction, Tsai found that using the Internet for studying open-ended controversial issues increased the sophistication of students' epistemological beliefs about science (Tsai, 2008), and Kienhues, Stadler, and Bromme have demonstrated that reading multiple Web sources led to an advance in students' epistemic beliefs (Kienhues et al., 2011).

Understanding the epistemic nature of online learning processes may give us better tools for comprehending students' decision making during online learning. This study focuses on two online learning strategies that are critical for dealing with the multiple and complex nature of online knowledge: evaluation and integration of online sources.

Evaluating the Trustworthiness of Online Sources

As students search online, they need to sift through a wide variety of sources and critically evaluate their credibility and the accuracy, reasonableness, and support of the arguments presented (Brem, Russell, & Weems, 2001; Rouet, 2006; Wallace, Kupperman, Krajcik, & Soloway, 2000; Wiley et al., 2009). Students are thus required to pay attention to multiple source characteristics and interpret them appropriately. Studies have consistently shown that students experience considerable difficulties in understanding and applying website evaluation criteria (Brem et al., 2001; Hoffman, Wu, Krajcik, & Soloway, 2003; Kuiper, Volman, & Terwel, 2005; Mason et al., 2011; Mason & Boldrin, 2008; Mason et al., 2010a; Wallace et al., 2000; Walraven, Brand-Gruwel, & Boshuizen, 2008; Wiley et al., 2009). These studies indicate that many students do not seek out

source information or evaluate the trustworthiness of online sources spontaneously; and when they do so, they often rely on superficial source characteristics that are poor indicators of source reliability such as visual cues, quantity of information, ease-of-use, and surface relevance. Even when students do attempt to evaluate online sources critically, they often have difficulties applying evaluation criteria (Brem et al., 2001). Corroboration of multiple sources and seeking of scientific evidence are rarely used spontaneously as evaluation strategies (Wiley et al., 2009). In attempting to understand the reasons for these difficulties, researchers often note the importance of prior domain and topic knowledge for successfully evaluating websites (Hoffman et al., 2003; Rouet, Ros, Goumi, Macedo-Rouet, & Dinet, 2011; Walraven et al., 2008). Students' difficulties with website evaluation appear to be exacerbated by weak argumentation skills (Brem et al., 2001).

Finally, student difficulties in evaluating online sources may also stem from their epistemic thinking. Studies indicate that children tend to assume that what is posted on the Web is correct, and only when they learn more about the nature of the Internet, do they start viewing online information more critically (Kuiper et al., 2005; Walraven et al., 2008). Brem, Russell, and Weems identified an "absolutist" orientation to Web searching characterized by the tendency to look for "true" sites and "real" scientists and by the belief that, given enough time, one can arrive at a "right answer" with complete certainty (Brem et al., 2001). Mason and Boldrin (2008) found that students' beliefs concerning the justification of online information are, for the most part, naïve and that half of the students use the amount of information provided by the website as a criterion of credibility. Additionally, students rarely refer to judgments concerning the scientific nature of a source as an evaluation criterion (Mason et al., 2011).

Critically Integrating Multiple Online Sources

When individuals try to understand a controversial current affair, a complex medical problem, or the causes of a historical event, they often encounter multiple and conflicting accounts. Making sense of multiple accounts and forming an integrated understanding are important skills for understanding the world around us and making reasoned judgments (Bråten et al., 2011; Kienhues et al., 2011; Mason et al., 2011; Rouet, 2006; Wineburg, 1991; Wolfe & Goldman, 2005). The integration of multiple documents is a complex strategy that requires forming a coherent representation of sources' content, noting the connections between source and content (knowing "who said what and why"), understanding the relations between different types of sources with multiple perspectives, and forming meaningful inter-textual content links, such as contradiction or support (Bråten et al., 2011; Perfetti, Rouet, & Britt, 1999; Rouet, 2006). However, studies reveal that students find it difficult to use multiple sources to construct an integrated account; instead, they frequently consider their task to be the accumulation of information (e.g., Rouet, 2006; Wineburg, 1991; Wolfe & Goldman, 2005).

One of the epistemic challenges posed by the Internet is the immediate access it offers to multiple and often conflicting accounts, a characteristic that creates the exciting potential for introducing authentic controversies into the classroom. However, the challenge of studying multiple texts appears to be enhanced by the nature of online sources. Studies demonstrate that students tend to "hop" from one website to another without engaging in systematic knowledge construction (Wallace et al., 2000). Students often assume that the answer is "out there" on a

website and spend their time looking for such a website, instead of attempting to construct an answer from multiple websites (Kuiper et al., 2005; Wallace et al., 2000).

Students' ability to integrate multiple sources may be related to their epistemic thinking. Bråten, Strømsø, and colleagues report a strong connection between epistemic beliefs and the comprehension of multiple documents, suggesting that only students with sufficiently sophisticated or adaptive views of knowledge are able to profit fully from such tasks (Bråten, 2008; Bråten & Strømsø, 2006, 2010; Bråten, Strømsø, & Samuelstuen, 2008; Strømsø et al., 2008, reviewed in Bråten et al., 2011). Students who view knowledge as complex are more likely to form connections between texts and achieve better comprehension of multiple documents, and students who view knowledge as tentative and uncertain profit more from challenging argumentation tasks related to conflicting sources (Bråten et al., 2011). The studies mentioned above have investigated how high school and university undergraduate students read and comprehend multiple print documents. Our study examines whether or not epistemic thinking is related to the critical integration of multiple sources among elementary school students in the specific context of online learning.

THE PRESENT RESEARCH

The goal of the current study is to examine epistemic thinking in action in order to shed light on the relation between students' personal epistemologies and their online learning practices. In order to do so, we studied students' epistemic thinking about evaluation of website trustworthiness and about integration of multiple websites in the context of two online inquiry tasks. We examined several aspects of students' epistemic thinking: their epistemic cognition, their epistemic metacognitive knowledge about persons (EMKP), and their epistemic metacognitive knowledge about strategies and tasks (EMKS). We also considered the role students' absolutist, multiplist, and evaluativist epistemic perspectives play in their online learning strategies. Table 1 summarizes the definitions of the study variables.

Our research questions were:

1. What is the nature of students' epistemic thinking about evaluation and integration of online sources? What epistemic issues arise as students evaluate and integrate multiple websites?
2. What role do differences in students' epistemic perspectives play in their epistemic thinking about evaluation and integration of online sources?
3. Is students' epistemic metacognitive knowledge about strategies of evaluation and integration of online sources related to their epistemic cognition regarding these strategies?

Kuhn and colleagues investigated epistemic development by examining how people respond to conflicting accounts. In this study, we analyzed students' epistemic perspectives in a similar fashion by asking students how they would deal with conflicting websites. We then examined how these epistemic perspectives come "in action" in the course of evaluation and integration of online sources. Our approach identifies developmental differences in students' epistemic perspectives, while recognizing that context also has an important role in shaping their epistemic reasoning (Kuhn et al., 2008).

TABLE 1
Description of the Study Variables

Variable	Description
Epistemic Perspectives*	
Absolutist	Knowledge is facts that are correct or incorrect, located in the external world, and certain.
Multiplist	Knowledge is opinions that are multiple, located in the individual, and uncertain.
Evaluativist	Knowledge is judgments that are constructed by the individual. Although judgments are uncertain they can be evaluated based on criteria of argument and evidence.
Facets of Epistemic Thinking	
Epistemic Cognition (EC)	Thinking about the epistemic characteristics of specific information or information sources.
Epistemic Metacognition (EM)	Thinking about the nature of personal knowledge and knowing, other persons' knowledge and knowing, and knowledge and knowing in general.
Epistemic Metacognitive Knowledge (EMK)	Knowledge, beliefs, ideas, and theories regarding knowledge and knowing in general.
Epistemic Metacognitive Knowledge about Persons (EMKP)	Knowledge about the nature of knowledge and knowing; including personal knowledge about the individual as knower, knowledge about other people as knowers, and knowledge about human knowledge in general.
Epistemic Metacognitive Knowledge about Strategies and Tasks (EMKS)	Knowledge about how to carry out an activity that will result in knowing; including knowledge about when, why, and how to use strategies for knowing, and about the epistemic nature of tasks.

*Based on Kuhn and Weinstock (2002).

METHOD

In-depth examination of students' epistemic thinking requires the use of qualitative methods, specifically real-time observations. We worked individually with sixth-grade students on two online inquiry tasks in order to observe closely individual epistemic thinking and its relation to the decisions made when learning online. Students were asked to think aloud during the tasks and reflect about the websites they used. Each task was immediately followed by a retrospective epistemic interview related to the task context (Hofer, 2004). We observed and analyzed two online inquiry strategies: evaluation and integration of online sources. In each strategy, we examined three facets of students' epistemic thinking: epistemic cognition, EMKP, and EMKS. Additionally, students were assigned to epistemic perspectives based on interview questions similar to those used by Kuhn and colleagues (Kuhn et al., 2000; Kuhn & Weinstock, 2002). We analyzed the role students' epistemic perspectives played in their online learning strategies and examined if, when, and how these epistemic perspectives were activated.

    We applied a mixed-method approach to the data analysis by combining qualitative and quantitative analysis techniques (Creswell & Plano Clark, 2006). We began by creating codes in a

bottom-up qualitative fashion and then applied these codes systematically. This enabled us to create a detailed qualitative description of the data. However, because our grounded qualitative analysis resulted in numerous categories, we could not test each category individually for significance. Therefore, in order to provide support to the trends that appeared to emerge from the qualitative analysis we quantified our codes, grouped and summarized them, and applied statistical procedures in order to test the significance of the connections between students' epistemic cognition and their epistemic metacognition, and in order to compare students with different epistemic perspectives (Chi, 1997). Because of the low number of students, we tested the data for normality before applying statistical tests (Tabachnick & Fidell, 1989).

Participants

Our participants were Hebrew-speaking sixth graders, from a mid-size city in the center of Israel. The initial number of participants was 42, 21 girls and 21 boys. The study was conducted in the students' homes, so participation was voluntary and required both student and parental consent. We approached several elementary schools and invited all the sixth graders in those schools to participate in the study. The volunteer rate in these schools was low (approximately 11%). We accepted all students who volunteered for the study with the one caveat described below.

Use of the Internet in Israel is widespread in both schools and homes (Nachmias, Mioduser, & Forkosh Baruch, 2009; World Health Organization, 2008). All of our participants had Internet access at home and most used the Internet on a daily basis. All of the participants had Internet at school and most used it there every week. In our background questionnaires, all of the participants reported high self-efficacy regarding use of the Internet and the Google search engine.

Because one of the goals of this study was to compare how students with different epistemic perspectives handle online information, we used Kuhn and colleagues' epistemological thinking assessment (Kuhn et al., 2000) to initially screen students' epistemic perspectives. We used this measure to select one third of the participants ($n = 14$, 7 boys and 7 girls) in each of the three epistemic perspectives defined by Kuhn and colleagues (absolutism, multiplism, and evaluativism). Once we had enough students in a certain epistemic perspective, we stopped accepting additional students with that epistemic perspective. We did not make any further use of the epistemological thinking assessment other than for this purpose of initially screening our participants.

Materials

Prior Knowledge Questionnaire.   This questionnaire asked the students to answer in writing the inquiry questions used in the online tasks (e.g., "Is chocolate healthy? Why?") The questions were open-ended and the students were asked to explain their answers. The questionnaire included four questions, two from the online tasks and two distracters.

Online Tasks.   We used two online inquiry tasks to examine students' epistemic thinking in varied settings. Both tasks involved the use of authentic websites in order to investigate open-ended and complex scientific questions that have multiple and conflicting answers online.

However, there were differences between the tasks in both topic and design. The first task was an open search task in which students were asked to search for information that would enable them to answer the question: "Is chocolate healthy?" In this task, the students searched independently and could decide how many and which websites to read. The primary aim of this design was to study the role epistemic thinking might play during student-controlled online searching. However, because we could not ensure all of the students would indeed encounter conflicting answers, we designed a second task in which students were provided with links to three pre-selected contrasting websites and were asked to read them in order to answer the question "Do the fish farms in the Gulf of Eilat harm the coral reefs?" This task did not involve searching, and all of the students read the same three websites. The primary aim of this design was to examine the role students' epistemic thinking might play when reading websites that provide different answers to the same question.

These tasks were chosen after extensive piloting. We had several considerations in choosing the inquiry topics: Both topics were scientific (although one related to health and one to the environment); both entailed complex and open-ended questions for which more than one answer could be found online; and, no less important, both were found to be engaging and motivating among the sixth graders we piloted. Additionally, there was a sufficient number of websites that provided accessible information regarding these topics, such as popular science articles in daily newspapers, health websites, advocacy websites, or websites for kids. Last but not least, students had sufficient background knowledge that could help them comprehend the information they read; nutrition, health, and the effect of human activity on the environment are standard topics of the Israeli science curriculum throughout elementary school. Thus, although students were not necessarily familiar with the specific questions we asked, they were familiar with similar types of questions and considerations.

Chocolate task (open search task).   We presented the question "Is chocolate healthy?" to the students and then asked them to use Google to search for information that might help to answer it. We gave no further instructions, other than asking them to think-aloud as they conducted their search (see Procedure section). Students were free to enter and leave sites as they wished. The task ended when students indicated that they were finished or after 20 minutes, whichever happened first. The students found a wide range of online sources, including Wikipedia, articles in several online newspapers, health related websites, and websites of chocolate fans, chocolate stores, and a school. These websites provided different accounts: Some extolled the virtues of eating chocolate; some reported results from scientific studies suggesting that the ingredients of chocolate are beneficial; some provided scientific results claiming that the ingredients of chocolate are harmful; and some offered more qualified and balanced accounts indicating that the effects of chocolate depend on the type of chocolate (percentage of cacao, for example), the amount consumed, and the health condition of those who eat it.

Fish farms task (pre-selected websites task).   The Gulf of Eilat (Aqaba) in the Red Sea is famous for the reefs found in the Coral Beach Nature Reserve. In the mid 1990s, commercial fish farms were built in the Gulf of Eilat in which fish were grown in underwater cages. The effects of the fish farms on the Gulf and the coral reefs have been one of the biggest environmental controversies in the history of Israel. The controversy died out several years ago when the Israeli

planning authorities decided that because of potential risk to the marine environment, the farms would be gradually shut down and the cages removed. At the time of the present study, this decision had already been reached, but the fish farms were still in place.

The task included a very short introduction explaining to students what fish farms are. Students then read three pre-selected websites in order to search for information that could help to answer the question "Do the fish farms in the Gulf of Eilat harm the coral reefs?" The websites included one that was in favor of the fish farms, one that was against, and a two-sided website. All websites provided scientific data in support of their arguments. The first website was written by students and teachers in a regional school in the Eilat area with ties to an organization that owned and operated one of the fish farms. The site claimed that the farms were an important source of employment and income and cited a report by international scientists that the farms did not harm the environment. The second website belonged to the environmental organization Clear Waters, which led the battle against the fish farms. The Clear Waters website claimed that the fish farms were destroying the coral reefs and cited scientific evidence to that effect. The third was the Israeli Ministry of Environmental Protection's website for children. This site stated that the pollution of the Gulf of Eilat has many causes and reported the controversy between fish farmers and environmental organizations concerning the effects of the farms. Although the governmental website presented both positions, it did not offer any suggestions about how the contradictions between them could be reconciled. Each website included a single page that the students were asked to read in its entirety.

Procedure

We initially met the students at school and asked them to fill out a questionnaire about their background in using computers, a Hebrew-language version of the epistemological thinking assessment (Kuhn et al., 2000), and the prior knowledge questionnaire. Approximately three weeks later, we met each student in her or his home after school hours and conducted an online task and a follow-up interview. One week later we visited the students again and conducted the second online task and interview. The sessions with the students were usually 30–45 minutes long. All of the students completed the tasks in the same order, first the chocolate task and second the fish farms task. We chose not to counterbalance the order of the tasks because we assumed that presenting students with three contrasting websites in the fish farms task might result in raising their awareness of the conflicting nature of information on the Internet and affect their performance in the more neutral open-search task. This study contains findings from the prior knowledge questionnaire, the online tasks, and the follow-up interviews, therefore we report only on their data collection and coding.

Think-Aloud.   In the process of searching the Web and reading the online sources, students were asked to think aloud about what they were doing. This technique makes it possible to study epistemic thinking in context, as a situated aspect of cognition. Think-aloud studies have been used successfully in studies of epistemic thinking (Hofer, 2004; Mason & Boldrin, 2008; Wineburg, 1991). We did not use the neutral type of think-aloud protocol proposed by Ericsson and Simon (1993), but rather employed a "prompted" think-aloud approach in order to elicit

students' self-explanations (Chi, 1997; Cotton & Gretsy, 2006). Prompts such as "What are you thinking about now?" "Why did you enter this website?" and "What is your opinion about this website?" were posed during pauses in the think-aloud commentary (see list of prompts in Appendix A). The interviewer also followed up on students' reflections by asking them to explain why they decided to take a certain course of action or why this was their opinion of the website. Prompting students to reflect about websites and explain their decisions may have raised their awareness regarding the sources they read and may have improved their comprehension (Chi, De Leeuw, Chiu, & Lavancher, 1994). Nonetheless, these prompts were highly instrumental in revealing the nature of students' thinking about online sources and provided us with rich data. In order to train the students to think aloud, we conducted a short warm-up activity before the first task. Students were asked to demonstrate to the interviewer how they use the Google search engine and to articulate their thoughts out loud, using the same kind of prompts. This warm-up activity lasted up to 5 minutes.

Retrospective Interviews.   Immediately after each task, we conducted a retrospective interview related to the task context. The interview was semi-structured in the sense that we followed up on the students' responses to our questions, returning to our protocol only when the topic seemed to be exhausted. The interview was an extensive one that included some of the questions used by Kuhn and colleagues in various studies (Kuhn, 1991; Kuhn et al., 2000; Weinstock & Cronin, 2003) as well as questions about online learning. Several interview questions related to evaluation and integration of online sources and were designed to elicit students' EMKP and EMKS regarding these strategies (see Tables 2 and 3). In the present article, we report only on the results of the interview sections that were used in order to analyze students' epistemic perspectives and their epistemic thinking about evaluation and integration of online sources (see relevant interview questions in Appendix A).

Data Collection

Questionnaire data were collected in writing. The tasks were conducted on a laptop computer equipped with a cellular modem. Screen capture software was used to make video recordings of the students' performance of the online tasks; the program also recorded students' verbalizations. Tracking software was used to measure students' surfing times in the open-search task: for example, how much time they spent in each website they entered. Students' verbalizations in the tasks and interviews were transcribed in full, resulting in approximately 1,000 pages of text.

Analysis

Coding Epistemic Perspectives.   Students' epistemic perspectives were assessed through a series of questions taken from Kuhn et al. (2000) and posed near the end of each interview:

TABLE 2
Data Sources and Codes for the Evaluation of Website Trustworthiness Strategy

Epistemic Facet	Data Sources	Codes

Epistemic Cognition	Students think-aloud reflections during the task	• Assesses content and form only
		• Notes source characteristics
		• Evaluates source trustworthiness based on:
		  ○ authority,
		  ○ expertise,
		  ○ scientific evidence or research,
		  ○ perspective or bias.

Epistemic Metacognitive Knowledge about Persons (EMKP)	Interview questions: • In your opinion, were the websites you entered good? Why? • What is a good website?	Evaluation criteria: • Relevance, usability, design, amount of information • Popularity, familiarity, type of website • Trustworthiness based on authority • Trustworthiness based on expertise, scientific evidence or research, or perspective/bias
Epistemic Metacognitive Knowledge about Strategies and Tasks (EMKS)	Interview question: • How can you know if a website is good?	Evaluation strategies: • Examining relevance • Assessing usability or design • Checking if information is sufficient • Relying on popularity, recommendations, or familiarity • Evaluating trustworthiness by examining content • Evaluating trustworthiness through corroboration with other websites

- If two websites make opposite claims about the question ". . . .," can only one site be right or could both be somewhat right?
  - If students say that only one can be right: Why? How can you tell which one is right?
  - If students say that both be somewhat right: Why? Could one of the websites be more right than the other, or are they both equally right?
    - If students say that one cannot be more right than the other: Why?
    - If students say that one can be more right than the other: Why? How can you tell which one is more right?

In general, students who thought that only one website can be right were classified as absolutists. Students who thought that both websites can be right and that one cannot be more right than the other were classified as multiplists. Students who thought that both websites can be right but that one can be more right than the other were classified as evaluativists. However, because the questions were posed to the students during an interview, and not through a written assessment, we could prompt students to explain the reasons underlying their opinions and choices and continue probing until we had a detailed description of their considerations. Thus, students were assigned epistemic perspectives only after careful analysis of the views of knowledge they expressed in a

TABLE 3
Data Sources and Codes for the Integration of Multiple Online Sources Strategy

Epistemic Facet	Data Sources	Codes

Epistemic Cognition	Students think-aloud reflections during the task and the interview questions:
	• What is your answer to the question?
	• Why is that the answer?
	• How do you know that this is the right answer?
		• Identifies website points of view correctly
		• Website comparison:
		  ○ No comparison or surface comparison
		  ○ Compares content
		  ○ Compares points of view or trustworthiness
		• Bases argument on multiple websites

Epistemic Metacognitive Knowledge about Persons (EMKP)	Interview questions:
	• Can there be a single website with the right answer to this question?
	• If yes, what kind of website would it be? If not, why?
		• Views of knowledge as constructed from multiple sources:
		  ○ Answer can be found in a single website
		  ○ Answer should be based on multiple websites
		• Reasons for the above positions:
		  ○ Amount of information
		  ○ Trustworthiness
		  ○ Multiple perspectives

Epistemic Metacognitive Knowledge about Strategies and Tasks (EMKS)	Interview question:
	• What would you do if you found two websites that make opposite claims about this question?
		• Strategies for choosing websites:
		  ○ Choosing a single website
		  ○ Considering more than one website
		• Strategies for dealing with multiple websites:
		  ○ Choosing among answers based on authority or plausibility
		  ○ Choosing among answers based on justification or corroboration
		  ○ Integrating multiple perspectives

lengthy interview section. Specifically, we paid careful attention to the reasons provided by the students in order to explain *why* one website could be more right than the other. If students gave an answer based on authority (e.g., "I would choose the more well-known website" or "I would ask my Mom"), or if they gave an answer based on plausibility or prior knowledge without explicit reasoning or evaluation (e.g., "I would choose the one that makes more sense to me"), their perspective was coded as absolutist. Only when students said that both websites could be right, that one website could be more right than the other, and exhibited reasoning about the justification of multiple perspectives or awareness of the constructed nature of knowledge did we code the students' perspective as evaluativist. In the absence of such evidence, the epistemic perspective was coded as absolutist or multiplist. This assessment method provides a rough indication of where individuals are in the progression from absolutist to multiplist to evaluativist thinking (Kuhn & Weinstock, 2002).

When students presented different epistemic perspectives in the two tasks, we decided to assign them to an epistemic perspective based on the highest level of epistemic thinking they exhibited. We believe that there may be a significant difference between a student who exhibits consistent absolutist reasoning, and one who exhibits evaluativist reasoning in at least one of the tasks. A consistent absolutist may be unaware of the constructed nature of knowledge. By contrast, inconsistent students demonstrate that they have a capacity for evaluativist thinking, but

apply this capacity in an adaptive way based on their interpretation of the task at hand. We believe this adaptivity can be interpreted as a sign of sophisticated epistemic thinking (Bromme et al., 2008, 2010; Elby & Hammer, 2001).

Coding Prior Knowledge.   Students' prior knowledge was assessed according to their written answers in the prior knowledge questionnaire. We scored students' answers by giving 0 points to those who answered "I don't know" in response to the inquiry question, 1 point for a positive or negative answer, and 2 points for a two-sided reply. An additional 1 point was given for each reason that students provided in support of their answer. For example, the reply "Yes and no, chocolate is healthy because it energizes you, and it is not healthy because it is fattening" got 4 points: 2 points for the two-sided reply and 1 point for each of the two reasons provided ("it energizes," "it is fattening").

Coding Epistemic Thinking About Online Learning Strategies.   Analysis of students' epistemic thinking began by reviewing the video recordings and reading the protocols of a quarter of the tasks and interviews (21 protocols), coding them in an open fashion, and looking for recurrent themes. We then organized the codes according to strategy (evaluation and integration). Although students combine evaluation and integration as they construct knowledge online, we chose to examine each of these strategies separately because they serve different goals and require somewhat different sets of knowledge and skills. In each strategy we looked for themes that related to three facets of epistemic thinking: epistemic cognition, EMKP, and EMKS. We worked in a bottom-up fashion by identifying recurrent themes in students' think-aloud and interview protocols that related to each of these facets. To avoid circularity, we used different sections of the think-aloud and interview protocol as data sources for each facet (see Tables 2 and 3). We examined the reliability of our coding scheme through interrater reliability (see below), refined it, and then reapplied it to the entire data set. The data was coded with the help of qualitative analysis software (Atlas.ti 5.6).

We used a fairly elaborate scoring scheme in order to quantify the data. We attached a score to each of the codes and used those scores to calculate a total score on a range of 0–6 for each facet (epistemic cognition, EMKP, and EMKS) in each strategy (evaluation and integration). Our scores were based on an evaluation of the adaptivity of the strategies used or described by the students to the specific task contexts. The tasks in this study required students to form and justify judgments regarding scientific controversies. Therefore, criteria and strategies of evaluating website trustworthiness through identification of evidence, expertise, bias, and so on received a higher score than criteria and strategies that provide poor indication of website trustworthiness, such as relevance, usability, or popularity (Brem et al., 2001; Britt & Aglinskas, 2002; Wiley et al., 2009). Likewise, strategies for critically integrating multiple sources received a higher score than strategies for accumulation of information or a simple choice among answers (Kuiper et al., 2005; Wallace et al., 2000). Tables 2 and 3 provide an overview of our codes. The description of the codes is included along with the results. A detailed explanation of our scoring procedures and considerations is provided in Appendix B.

Interrater Reliability.   Interrater reliability was examined for about 25% of the protocols with the help of two raters who were not involved in the data collection and analysis. The first author and one of the other raters examined the reliability of the coding of the epistemic perspectives.

The rate of agreement for the epistemic perspective codes was 91%. The first author and another rater, who was not aware of the students' epistemic perspectives, examined the reliability of the coding of the online learning strategies. The preliminary rate of agreement between raters was usually 80–100%. Codes with an agreement rate of less than 80% were discussed, modified, and checked again with a new sample. In one case, the resulting rate of agreement was still less than 80% and the code was dropped. The final interrater reliability for the online learning strategy codes averaged 94%.

RESULTS

We begin the presentation of the results with data regarding students' epistemic perspectives, prior knowledge, and searching behavior. The central part of the results is devoted to exploring students' epistemic thinking about evaluation and integration of online sources. In each strategy, the results are organized in four sections: epistemic cognition, EMKP, and EMKS, and a section titled "epistemic thinking in action" that explores the dynamic relation between cognitive and metacognitive facets of students' epistemic thinking. These sections offer a qualitative description the performance of all the participants and present descriptive statistics regarding notable differences between groups and tasks. In order to examine the trends that appear to emerge from the qualitative analysis, the last section of the results provides tests of the significance of students' epistemic perspectives and of the effect of strategy and task contexts.

Students' Epistemic Perspectives

Most students exhibited the same epistemic perspective in both tasks. Six students out of 42 presented an absolutist perspective in the chocolate task and an evaluativist perspective in the fish farms task. These students were classified in further analyses, as explained earlier, according to their highest epistemic capacity, as evaluativists (see Table 4).

The epistemic perspectives of the students in the contexts we studied included a low percentage of multiplists (7%) and a substantial percentage of evaluativists (43%). This pattern is consistent with observations made by Kuhn and colleagues that certain problem contexts prompt a greater degree of evaluativist thinking, even among sixth graders (Kuhn et al., 2008). There were considerable differences between the epistemic perspectives assessed by the initial epistemological thinking assessment and those assigned in the task contexts. These differences may have resulted from different measurement techniques (written measure versus interview), different coding procedures (in the interview we coded students' reasoning and not just their end-conclusion), and

TABLE 4
Epistemic Perspectives

Epistemic Perspective	Girls	Boys	Total	%
Absolutist	11	10	21	50
Multiplist	2	1	3	7
Evaluativist	8	10	18	43
Total	21	21	42	100

lastly, the effect of context. For example, perhaps when students who were evaluated as multi-plists based on the written assessment interacted with a task that presented an authentic dilemma in a rich context, they felt more compelled to take a side and form a conclusion by adopting an absolutist or evaluativist perspective. It may also be possible that the multiplist responses in the epistemological thinking assessment did not reflect a truly multiplist perspective but rather students' uncertainty about which account could be "right" or "more right."

Because the number of multiplists was so low (3 students), they were not included in subsequent analyses. Also not included in subsequent analyses was one absolutist who preferred to conduct her searches on YouTube and whose online learning strategies were therefore not comparable with those of the other students. The final number of students in the analyses was therefore 20 absolutists and 18 evaluativists ($n = 38$).

Students' Prior Knowledge

Students' prior knowledge concerning the chocolate dilemma ($M = 3.50$, $SD = 1.11$), was, as expected, significantly higher than concerning the fish farms dilemma, ($M = 1.16$, $SD = 1.15$), $t(37) = 9.55$, $p < .001$. There were no significant differences between the absolutists' and evaluativists' prior knowledge concerning the chocolate dilemma, $t(36) = -.876$, $p = .387$, or the fish farms dilemma, $t(36) = -.044$, $p = .965$.

Searching Characteristics

In the open-search task "Is chocolate healthy?" students conducted 1–4 searches in Google (about 2 on average) and read 1–4 websites (about 2 on average). There were no significant differences between absolutists and evaluativists in the number of searches, number of sites read, or in searching and reading times.

Evaluating the Trustworthiness of Online Sources

Epistemic Cognition.   During the tasks, students made multiple think-aloud references to the characteristics of the websites they read. We prompted students to reflect on the websites by asking them, "What is your opinion about this website?" This prompt was intentionally phrased in an open manner in order not to influence students' reflections. Students' references to the websites they read were organized into three main categories: (a) assessing content and form, (b) noting source characteristics, and (c) evaluating source trustworthiness.

(a) Assessing content and form.   Students' reflections on content and form were ubiqui-tous. Students were quite efficient in deciding whether or not a site contained relevant information, if it told them something new, and if its language level was appropriate to their reading ability. They were also highly attentive to design issues, text length, and font size. Poorly designed sites, or sites with low readability, were quickly rejected. Sometimes content and form were the only

issues that concerned the students, while disregarding the nature of the source. This finding is consistent with findings from previous studies indicating that students often do not spontaneously attend to source characteristics (Brem et al., 2001; Britt & Aglinskas, 2002; Kuiper et al., 2005; Wiley et al., 2009). For example, Sharon entered a website called "The Ultimate Chocolate Website" that was owned by a chocolate store and presented very positive information about the health benefits of chocolate. Sharon did not note the site's name or ownership but focused exclusively on its content:

> Interviewer: What is your opinion about this website?
> Sharon: It's great.
> Interviewer: Yes? Why?
> Sharon: Because it's pretty detailed and it has a lot of things that are related to chocolate like history, and health, and types of chocolate, and recipes.

(b) Noting source characteristics.   Students did sometimes note source characteristics. However, this was often done without explicitly using these characteristics to evaluate source trustworthiness. The source characteristics most frequently noted by the students were: familiarity, popularity, Google ranking, website title, author name, type of website, and target audience. Students preferred familiar or popular websites, and if they did not find such websites, relied heavily on Google ranking. Students used these source characteristics for identifying "good" websites quickly; "good" usually meant sites where the required information could be found rapidly and easily without the need to seek additional websites. For example, in the chocolate task, Aviv typed in Google, "Is chocolate healthy?" and then chose the first website in the Google search results, explaining:

> Aviv: I just type the question you asked me, with a question mark, and search Google. I check if there is [a result from] Wikipedia . . . and if there isn't, I open the first link.
> Interviewer: Why do you open the first one?
> Aviv: Because I think it has the most information.

(c) Evaluating source trustworthiness.   Students were sometimes sensitive to the reliability of the websites they read. Students evaluated the trustworthiness of the sources in several different ways, the most common of which were based on:

- *Authority*—Students rated sites as more trustworthy if they were familiar, well known, or "professional." These judgments of website trustworthiness were not based on an evaluation of the expertise or credentials of the website authors (e.g., "Everybody knows this website, so you know it has reliable stuff" [Aviv]).
- *Expertise*—Some students noted whether or not a site was written by experts or cited experts, such as doctors, nutritionists, and scientists and used that information as an indicator of trustworthiness (e.g., "This site was built by students and teachers, and so they might be wrong because they are not experts" [Yarden]).
- *Scientific evidence or research*—Another indicator of trustworthiness was whether or not the site included scientific evidence for its claims or described the results of scientific research

(e.g., "Here it says 'studied by researchers from Italy and Scotland, with 12 healthy volunteers . . . ' - and all sorts of things like that, so this looks good, it looks like a reliable source" [Amir]).

- *Perspective or bias*—Finally, there were students who paid attention to the perspective or bias of the sites' owners or writers and used it to determine the trustworthiness of the websites' claims (e.g., "This could be, for instance, a website that just some people built. Like, just some people from the fish farms. They built it to show that they [the fish farms] do not harm" [Yarden]).

Most students expressed multiple website evaluations. Figure 1 reports the frequency of each evaluation category as a percentage of the websites it was applied to on average in both tasks (that is, 94% indicates that students made this type of evaluation regarding 94% of the websites they read on average). The most frequent evaluation category was "assessing content and form" (87% of the websites on average). Students noted the source characteristics of only approximately half of the websites (54% of the websites on average) and evaluated the trustworthiness of online sources even less (39% of the websites on average). There did not seem to be notable differences between absolutists and evaluativists.

Figure 2 presents the frequencies of the website trustworthiness criteria applied by the students to the websites they read. Students evaluated the reliability of websites most frequently by referring to their authority (36% of the websites on average). Use of evaluation criteria such as expertise, scientific evidence, or authors' biases was low (10–13% of the websites on average). The differences between absolutists and evaluativists appeared to be minor. Use of scientific evidence or expertise by absolutists is not unexpected; Kuhn and colleagues proposed that absolutists also engage in critical thinking but view critical thinking as a means for objectively determining truth or falsehood (Kuhn et al., 2000; Kuhn & Weinstock, 2002). Absolutists may use bias to discount one account or credit another (e.g., "The Fish Farms website . . . tried to stall the argument and hold back evidence that the fish cages pollute and harm the coral reefs. They're just trying to confuse the issue, in my opinion" [Yishay]).
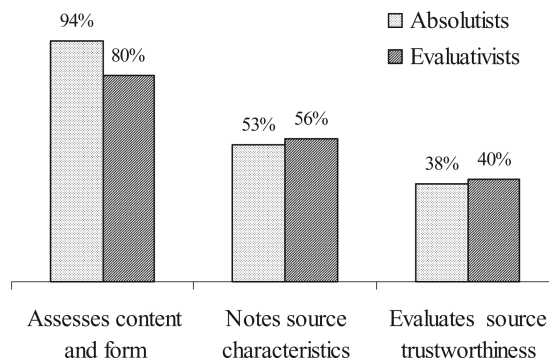

FIGURE 1 Evaluating Websites: Epistemic Cognition. Columns represent the average percentage of websites in each category in both tasks.
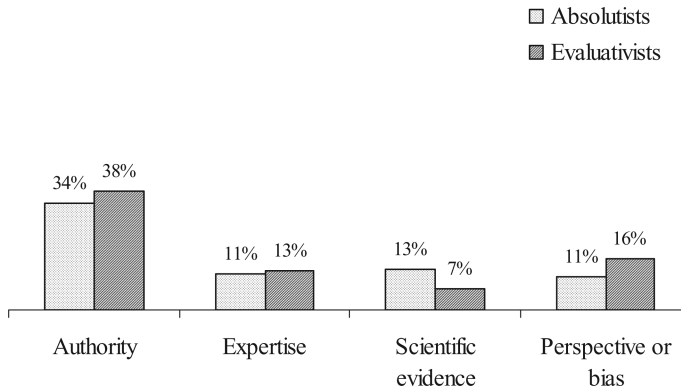
FIGURE 2 Evaluating Website Trustworthiness: Epistemic Cognition. Columns represent the average percentage of websites in each category in both tasks.

Epistemic Metacognitive Knowledge About Persons.   We examined students' EMKP regarding evaluation of online sources by asking them about their website evaluation criteria (e.g., "What is a good website?"). Students' explicit evaluation criteria generally mirrored the evaluations made on the cognitive level and were coded according to the same categories. In both tasks, an average 95% of the students described criteria relating to content and form, such as relevance, usability, design, and amount of information. Fewer students, 43%, mentioned criteria relating to source characteristics, such as familiarity or the type of website, without stating how these criteria could be used to evaluate trustworthiness. Criteria for evaluating the trustworthiness of online sources, such as authority, expertise, scientific evidence, perspective, or bias were explicitly mentioned by 52% of the students.

Students' EMKP regarding website trustworthiness evaluation criteria is presented in Figure 3. Evaluativists mentioned website perspective or bias as a criterion for evaluating trustworthiness more often than absolutists. This was especially apparent in the fish farms task in which 50% of the evaluativists mentioned website perspective or bias compared with 10% of the absolutists. The fish farms task context prompted greater awareness of diverse viewpoints among evaluativists than the chocolate context. This variance may have resulted from greater contrasts among the websites in the fish farms task. However, absolutists seemed to be less affected than evaluativists by the difference between task contexts. These impressions require additional analysis in order to examine their significance.

Epistemic Metacognitive Knowledge About Strategies and Tasks.   Students need not only be familiar with website evaluation criteria but also know how to apply them when searching the Web. However, when we asked "How can you know if a website is good?" we discovered that students often could not describe effective strategies for evaluating website trustworthiness. In both tasks, even students who exhibited a relatively high awareness of website evaluation
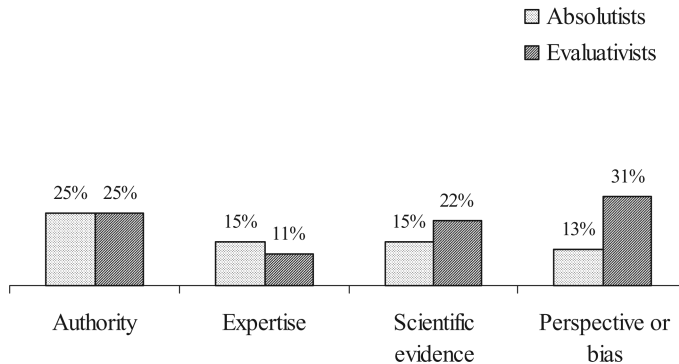
FIGURE 3 EMKP Regarding Website Trustworthiness Evaluation Criteria. Columns represent the percentage of students in each category in both tasks on average.

criteria found it difficult to explain how they would go about applying these criteria. As a result, students reverted to describing more superficial evaluation procedures, such as checking content relevance based on the website's title or abstract, deciding if the amount of information provided by the website was sufficient for answering the question, or basing the decision on popularity or recommendations by peers, teachers, or parents. Only a small percentage of students acknowledged that they had an option to evaluate website content (20% of the students, as in: "I try to find out what are the good things in the website and what are the bad things in the website . . . according to the material in it" [Eliran]), or the option to corroborate and thus evaluate trustworthiness (13% of the students, as in: "Like here you gave us three websites . . . and you can see that most of them were against [the fish farms]. They explain the same things and they justify each other, and so that's how I know if a website is good" [Yaron]). References to using scientific evidence or identifying website bias were even less common; only one or two students made such references. Figure 4 presents the website evaluation strategies that the students described most frequently. Most students reported multiple strategies.

Absolutists mentioned strategies such as examining relevance or choosing websites according to recommendations, familiarity, and popularity somewhat more often than evaluativists. By contrast, evaluativists mentioned strategies for evaluating the websites' usability and design somewhat more often than absolutists; they also described corroboration strategies slightly more often. The frequency of evaluativists' references to strategies related to usability and design is somewhat surprising; however, these strategies were almost always described along with additional website evaluation strategies (e.g., "[In the beginning you can tell if a website is good] mostly by its beauty, by the way it's arranged, not really by the information . . . but then you go in and you see what's inside. It's like with people—just as you don't judge someone by their looks but by their character, so with websites it's not by looks but by the content" [Lilach]).

Evaluation of online sources has been described in the literature as requiring a significant amount of domain knowledge and an understanding of argument structure students often lack (Brem et al., 2001; Hoffman et al., 2003; Walraven et al., 2008). Our results may perhaps indicate
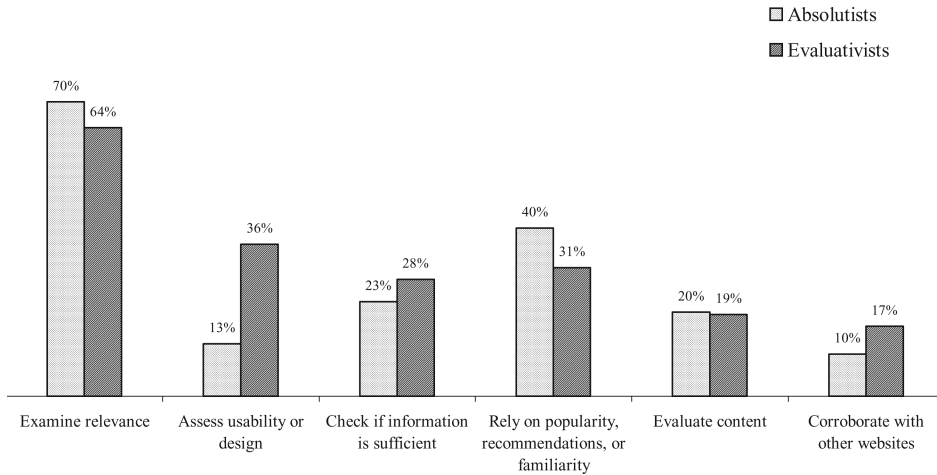
FIGURE 4 EMKS Regarding Website Trustworthiness Evaluation Strategies. Columns represent the percentage of students in each category in both tasks on average.

an additional problem: low EMKS about strategies for evaluating website trustworthiness, such as use of scientific evidence or identification of website bias. Absolutists and evaluativists alike had this problem in both tasks.

Epistemic Thinking in Action.   While much may be learned from analyzing different aspects of epistemic thinking, we propose that they are not isolated components but, rather, dynamic and highly interactive facets of students' thinking processes. We found both qualitative and quantitative evidence for the important role of epistemic metacognition in the students' evaluation of websites. Analysis of the protocols revealed that EMK is activated during the course of learning as well as shaped by online learning experiences. To illustrate these connections, we start by presenting an excerpt from the protocol of one of the girls who participated in the study, an absolutist named Sivan. In the chocolate task, the first website she entered was an article in an online newspaper titled: "Chocolate—healthy or not?" After skimming over the page, she left and started looking for another website. The interviewer probed:

Interviewer: Why are you leaving the website?
Sivan: Because usually other websites have more information. I never rely on only one site.
[Enters another site, reads, and comments briefly, then leaves and enters another site].
Interviewer: Why did you leave this website?
Sivan: Because . . . I don't know. Usually when I write a paper . . . for example today I wrote a paper for school about the atmosphere of the earth, so I searched for materials about the atmosphere. I copied all of the material. Then I read it and highlighted only the important things and deleted the rest. . . . And sometimes I take stuff from encyclopedias also. . . . For example, I had to write a paper about ancient Greece, so I went to the library and checked out books, and a little from the Internet and from encyclopedias.
Interviewer: So you use both books and the Internet.

Sivan: Yes, I never trust the Internet alone . . .
Interviewer: Why?
Sivan: Because we learned, in computer class for instance, that there are websites you cannot trust. Like, I could write something and then turn it into a website, and then you can't be sure if it's true.
Interviewer: I see.
Sivan: There are websites scientists create that include facts. But even the scientists are not always right.
[Continues reading]
Sivan: Here it says—"Chocolate can improve blood vessel function" [quotes]. It's exactly the opposite of what we read before! That's why you can't trust it.

Sivan brought to the task her EMKP that websites cannot be completely trusted and her EMKS that trustworthiness may be improved by corroborating multiple online and offline sources. This knowledge prompted her to seek more than one website and to compare the different accounts in order to establish credibility. At the same time, her direct experience with the conflicting nature of online accounts made her doubt what she read and strengthened her opinions regarding website trustworthiness. Sivan's underlying absolutist perspective is apparent in the way she analyzes trustworthiness in binary terms of right/wrong or true/false. In her view, trustworthy websites are sites created by scientists and include "facts." Unfortunately, scientists may be "wrong," and students face the difficult task of deciding which website is "true."

In addition, we found quantitative evidence for the connections between students' epistemic cognition and their epistemic metacognition. In order to examine the relations between epistemic cognition and students' EMKP and EMKS, we scored all three variables on a scale of 0–6 and calculated the average score in the two tasks. Significant correlations were found for all students ($n = 38$) between their epistemic cognition in the evaluation strategy and their EMKP concerning website evaluation, ($r = .54, p < .001$), as well as between their epistemic cognition and their EMKS concerning website evaluation ($r = .34, p = .039$). Students' EMKP and their EMKS were also correlated ($r = .51, p < .001$).

Critically Integrating Multiple Online Sources

Epistemic Cognition.   Evaluation and integration of online sources are related strategies. On the one hand, evaluation necessitates, among other requirements, the comparison and corroboration of multiple sources; on the other, critical integration requires accounting for differences among respective sources, such as differences in purpose, bias, and credibility. However, to assess the level of students' online source integration, we chose—based on the think-aloud protocols—several key indicators that together reflect the degree to which students were able to integrate accounts from multiple websites. These indicators were: (a) identifying points of view of multiple websites, (b) comparing websites, and (c) using multiple websites to construct an argument in response to the inquiry question.

(a) Identifying multiple website points of view.   In order to integrate multiple online sources, students need to be able to identify the position of each website. The ability to identify divergent points of view correctly is not only an indicator of text comprehension but also reflects students' awareness of the differences between accounts. Markman (1977, 1979) demonstrated

that students often ignore blatant contradictions and inconsistencies. In our study, too, students frequently ignored or misunderstood explicit contradictions and differences between websites. We did not attempt to assist students by pointing out their misunderstandings. Evaluativists consistently identified website points of view correctly more often than absolutists in both tasks. On average, 61% of the evaluativists identified two or more of the websites' viewpoints correctly, compared with 38% of the absolutists.

(b) Comparing websites.   One of the key components of integration is forming content connections, such as contradiction or agreement among multiple sources. During the online tasks, students sometimes made explicit comparisons between websites. Many of these comparisons were surface comparisons of content relevance and website usability or design, but students also compared specific content items, points of view, and trustworthiness. For example, as Yotam read the second website in the fish farms task, he commented:

> But it says two different things. Here they say that the [fish farms] pollute, okay? But in the other site they said that they don't pollute and that it's almost . . . that the coral reef is almost the same as it was before [the fish farms were introduced]. [Yotam]

Yotam noted that the two websites present opposing positions: pollute versus do not pollute. Yotam also compared a specific content item, noting that the second site claimed the coral reef was almost destroyed because of the fish farms, while the first site claimed the coral reef was not harmed. Evaluativists made such point-of-view or content comparisons between websites more often than absolutists in both tasks. On average, 65% of the evaluativists made point-of-view or content comparisons, compared with 21% of the absolutists.

(c) Using multiple websites to construct an argument.   We examined the number of websites on which the students based their final arguments. For example, Ori said:

> In my opinion, the fish farms pollute the ocean because there can be diseases because of the over-crowding [of the fish], because they secrete food and other materials to the sea floor, and they kill a lot of corals. But not only they pollute the ocean, but also ships passing through, sewage water, waste from the hotels, they also pollute the Gulf. [Ori]

The information regarding the damaging effects of the fish farms appeared on the Clear Waters website. The information regarding other causes of pollution in the gulf appeared on the governmental website. Thus this complex argument was based on two websites. Evaluativists appeared to outperform absolutists according to this indicator as well. On average, 83% of the evaluativists based their arguments on two or more websites, compared with 48% of the absolutists.

Epistemic Metacognitive Knowledge About Persons.   We investigated students' EMKP concerning the constructed nature of Web-based knowledge through the interview questions: "Can there be a single website with the right answer to this question? If yes, what kind of website would it be? If not, why?" In both tasks, on average only 32% of the absolutists thought that the answer cannot be found in a single website, compared with 50% of the evaluativists. We

examined the reasons students provided for their answers and discovered three main categories of explanations: (a) amount of information, (b) trustworthiness, and (c) multiple perspectives.

(a) Amount of information. Many students held an accumulative view of knowledge. Some of them pointed out that if a single website provides all the necessary information, it is sufficient; other students thought that because websites usually provide different information, one website cannot be sufficient. Both types of the responses focused on the amount of information provided by the websites, not taking into account the possibility of different perspectives. For example, "In one site, something may be missing that you can find in the other site. There can be a website with more detailed information, a website that knows more" [Yaron].

(b) Trustworthiness. A second reasoning category pertained to the websites' trustworthiness. Some students thought that if a single website was reliable and credible, it could be a sufficient source of information (e.g., "If there's proof and everything then I'm sure there can be one website that can prove it" [Yishay]; "It can be a website like Wikipedia or a website that a lot of people use, and it is a well-known information website, so usually they provide correct information" [Guy]). Other students questioned the reliability of online sources and doubted that a single website could be a reliable source of information (e.g., "In order to know that it is the most correct answer, it's better to open more websites, and to verify it" [Yarden]; "You never know who wrote the website. You assume that the writer is someone you can trust . . . but there's also people just making fun out of it" [Amir]).

(c) Multiple perspectives. Finally, there were students who provided reasons that took into account the possibility of websites presenting different points of view. These responses reflected an awareness of the complex and constructed nature of knowledge. To explain why a single website could not be a sufficient source of information, some students mentioned differences in purpose or perspective (e.g., "There's all sorts of websites, all sorts of people. I think you can find a lot of answers in different places" [Maya]; "[A single website] might give me only one side" [Ori]). Other students stated that a single website might be sufficient only if it presents a two-sided perspective. For example:

> It should be a site that doesn't have a specific opinion. Because this site, it had a very clear opinion that the [fish farms] actually help, okay? But the two other sites had a very clear opinion that it harms and harms. You need a site of two people from here and two people from every other site who will build a site together that [says] that according to so-and-so, yes, it harms, and according to so-and-so, actually yes, in a certain way it helps. [Shiran]

Students were often concerned with information accumulation (60% of all students on average in both tasks) and, to a somewhat lesser degree, with website trustworthiness (49%), whereas multiple perspectives as a cause for knowledge integration were considered less frequently (25%). Evaluativists expressed awareness of the need to integrate knowledge in order to improve trustworthiness and to take into account multiple perspectives more often than absolutists (see Figure 5). Evaluativists referred to multiple perspectives more often in the fish farms tasks (56%
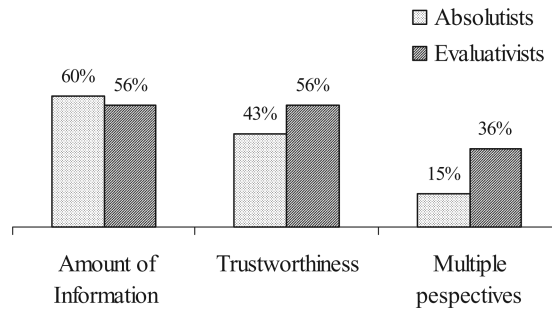
FIGURE 5 EMKP Regarding Reasons for Constructing Knowledge from Multiple Sources. Columns represent the percentage of students in each category in both tasks on average.

of the evaluativists compared with 20% of the absolutists) than in the chocolate task (17% of the evaluativists compared with 10% of the absolutists). This may perhaps indicate that the evaluativists were more sensitive to the differences between task contexts than the absolutists.

Epistemic Metacognitive Knowledge About Strategies and Tasks.   In order to investigate students' EMKS concerning the integration of multiple sources, we asked them: "What would you do if you found two websites that made opposite claims about this question?" Students described a wide range of strategies for dealing with conflicting websites, with most students depicting more than one strategy. The strategies described by the students were classified according to three main categories: (a) choosing between answers based on plausibility or authority, (b) choosing between answers based on justification or corroboration, and (c) integrating multiple accounts.

(a) Choosing between answers based on plausibility or authority.   The strategies in this category were characterized by a lack of reasoned justification and account integration. Students said they would choose the website that makes more sense or "feels" right (plausibility), rely on their prior knowledge without explicit reasoning, ask their parents or teachers which website was right (external authority), or choose the more well-known site (website authority). For example, "I would read both websites and choose the one that I think makes most sense" [Shlomit]; "I would ask the teacher" [Maor].

(b) Choosing between answers based on justification or corroboration.   Students referred to several methods of justification for choosing between multiple sources. These justification methods included examining the explanations and reasons provided by the websites, looking for scientific research or evidence, relying on expertise, and corroborating the information. Corroboration based on the comparison of different websites is an important step toward the integration of multiple accounts. However, students' understanding of corroboration was often superficial and naive. For instance, many of them said they would base their views on the majority opinion:

You can take four or five websites and see what there is more of. Like, I take an odd number of websites to see what there's more of and then I say: three said "yes," two said "no," and so the right answer is "yes." [Amir]

(c) Integrating multiple accounts.   Corroboration becomes more meaningful when it is accompanied by an attempt to examine and integrate the positions and arguments presented by different online sources. Students described various integration methods. For example, Maya explains:

When we write a paper, they always ask us to write down the sources. So I would write down the sources and say that here they say [chocolate] is healthy, and here they say it isn't healthy, and I would draw the conclusions. Like, there are some good things, very good things: it can help prevent strokes, and it's healthy and everything; but it is also not healthy and fattening and all of those things. [Maya]

Maya's solution to the problem of conflicting accounts is to view chocolate as having both positive and negative aspects. She decides to present a two-sided view of the problem and to note that there is a disagreement between different sources. Eliran also says that he would present both accounts but, in addition, he would attempt to arrive at some sort of "answer" to the question:

If I had an inquiry assignment, then I could show both sides, and give explanations and everything, and also say that it is not certain which of the sides is right and which is wrong, but I would still bring something that would explain and give an answer. [Eliran]

Figure 6 reports the range of strategies described by the students for dealing with conflicting websites. Many students spoke of using multiple strategies, such as combining plausibility assessment and corroboration or combining corroboration and integration.

Absolutists and evaluativists shared the same range of metastrategic knowledge about integration strategies. The difference between absolutists and evaluativists was in the distribution of
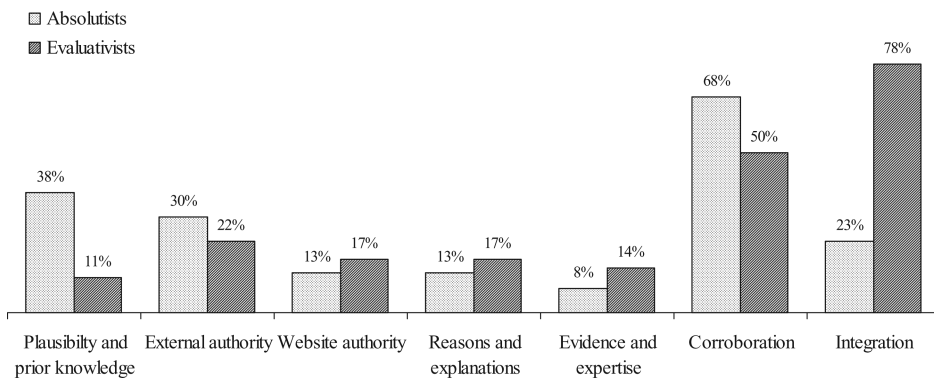

FIGURE 6 EMKS Regarding Strategies for Dealing with Conflicting Online Sources. Columns represent the percentage of students in each category in both tasks on average.

the strategies. Absolutists more often described strategies of assessing plausibility and authority and using corroboration. These strategies were generally characterized by a lack of reasoning about the conflicting arguments presented by the websites. Evaluativists, by contrast, mentioned strategies of integration of opposing accounts much more often than absolutists.

Epistemic Thinking in Action.   As described earlier, evaluativists identified, compared, and contrasted diverging points of view more often than absolutists. Some evaluativists actively focused on identifying points of view and searching for differences as their primary reading objective. The following excerpt from the task protocol of Neta, an evaluativist, demonstrates this pattern. When Neta read the second website in the fish farms task, the site created by the "Clear Waters" organization, she commented:

> Ah . . . "about 70% of the coral reef is already dead, and the entire coral reef is in immediate danger of collapsing." [quotes] This is really different from what they said in the other site. . . . They support [moving the] fish pools onto the land.

Neta continued to the third website and, after reading it for a few moments, reflected:

> Neta: They don't take sides. . . .
> Interviewer: Why do you say that?
> Neta: It claims that other things pollute [the Gulf]. It, like, shows the point of view of everybody.
> Interviewer: Okay.
> Neta: It doesn't relate to [only] one side.
> Interviewer: Where do you see that?
> Neta: Here, they write, like, about how it pollutes, about the marine agriculture: "growing sea fish in under-water cages in the Gulf of Eilat has been the focus of a large public debate". They don't say if it's good or bad. "The green organizations and the Ministry of Environmental Protection claim that fish secretions, food remains, and materials used by marine agriculture harm the quality of the sea water". *They talk about everybody in the third person.* [Emphasis added by the authors]

Neta is highly aware of the existence of multiple voices and perspectives and actively seeks out clues, such as the use of language, to help her identify the positions of the websites. These positions then become important in her interpretation and integration of the accounts. When asked in the follow-up interview, "What would you do if you found two websites that make opposite claims about this question?" she returned to the websites and reflected:

> Neta: Look at something interesting: "An international team of scientists appointed by the Ministry of Environmental Protection, the Ministry of Infrastructure, and the Ministry of Agriculture determined that marine life flourishes under the fish farms . . . " [quotes the first site]. And in this site [the third site], the site of the Ministry of Environmental Protection, they don't say that . . . *maybe it is against their interests*. . . . It's pretty confusing because you don't know what to decide. Because on the one hand, the Ministry of Environmental Protection has an interest to say that it harms because they want to take care of the environment. So I think that they took out some details, both sides [did]. . . . Sometimes you need a website that doesn't take sides. Really, a website that will tell you everything, without leaving any details out.
> Interviewer: A website that doesn't leave any details out because it doesn't suit them?

Neta: Yes, because it's very convenient, because it is not a lie, it's a sort of a white lie.
Interviewer: So they don't lie; they just don't put it in.
Neta: They don't put it in. That's their right, *it's their right to justify it.*
[Emphasis added by the authors]

As Neta noticed the differences between the websites, she interpreted them in terms of her beliefs about the motivated and constructed nature of knowledge. Unlike Sivan, the absolutist, who interpreted differences between accounts in terms of right or wrong, Neta understood the differences between the websites as resulting from the need to justify different perspectives. Neta developed her ideas about knowledge through her interaction with the conflicting online sources. Noticing the differences between the sources motivated her to form a complex explanation of the causes of these differences and how they may be understood. Neta's need to form an understanding of multiple accounts leads her to think about the perspectives and goals of the authors and the legitimacy of their justification methods.

We also found quantitative evidence for the relation between epistemic cognition and epistemic metacognition in the website integration strategy. Significant correlations were identified for all students ($n = 38$) between their epistemic cognition and their EMKP concerning the necessity of using multiple websites ($r = .36$, $p = .028$), as well as between their epistemic cognition and their EMKS concerning strategies for negotiating contrasting online sources, ($r = .60$, $p < .001$). Students' EMKP and EMKS regarding the integration strategy were not correlated, ($r = 0.17$, $p = .295$). This finding may indicate that students who were aware of the possibility that a single website may not be a sufficient source of information were not necessarily aware of strategies for critically integrating multiple websites.

Comparing Epistemic Perspectives

In order to test the significance of the trends that appeared to emerge from the qualitative analysis and to examine the differences between absolutists and evaluativists, we computed an overall score for each strategy in each task. The overall score ranged from 0 to 12 and was a sum of the epistemic cognition score (0–6 points) and the epistemic metacognitive knowledge score (0–6 points, an average of students' EMKP and EMKS scores). Overall score means and standard deviations are presented in Table 5. We then conducted a 2 × 2 × 2 Manova with epistemic

TABLE 5
Overall Strategy Scores: Means, Standard Deviations, and *t*-test Results

Strategy	Task	Absolutist Perspective (n = 20) M (SD)	Evaluativist Perspective (n = 18) M (SD)	t	p
Evaluation (0–12)	Chocolate	5.68 (3.21)	4.86 (2.61)	0.85	.400
	Fish farms	4.44 (4.24)	6.82 (3.80)	0.79	.078
Integration (0–12)	Chocolate	4.35 (2.94)	6.85 (2.27)	−2.91	.006
	Fish farms	5.40 (2.64)	8.85 (2.68)	−3.99	<.001

perspective (absolutists, evaluativists) as a between-subjects factor and task (chocolate, fish farms) and strategy (evaluation, integration) as within-subjects factors. The dependent variables were the overall scores for each strategy in each task.

The effect of epistemic perspective was found to be significant, $F(1,36) = 6.85$, $p = .013$, $\eta^2 = 0.16$. Also significant were the effects of strategy, Wilks' $\Lambda = 0.86$, $F(1,36) = 5.87$, $p = .021$, $\eta^2 = 0.14$, and the interaction between epistemic perspective and strategy, Wilks' $\Lambda = 0.81$, $F(1,36) = 8.47$, $p = .006$, $\eta^2 = 0.19$. The effect of task type was not significant, Wilks' $\Lambda = 0.91$, $F(1,36) = 3.70$, $p = .062$, $\eta^2 = 0.09$. But the interaction of task and epistemic perspective was significant, Wilks' $\Lambda = 0.89$, $F(1,36) = 4.45$, $p = .042$, $\eta^2 = 0.11$.

To interpret these results, we conducted independent sample t-tests for the overall scores using Holm's sequential Bonferroni method to adjust alpha levels. There were no significant differences between absolutists and evaluativists in the evaluation strategy. But evaluativists significantly outperformed the absolutists in the integration strategy in both the open-search chocolate task, $t(36) = -2.91$, $p = .006$, and the closed-search fish farms task, $t(36) = -3.99$, $p < .001$. We used paired-sample t-tests to compare tasks and discovered that among the absolutists there was no significant difference between the two tasks in regards to both strategies. However, evaluativists performed significantly better on the fish farms task than on the chocolate task in both the evaluation strategy, $t(17) = -2.50$, $p = .023$, and the integration strategy, $t(17) = -2.29$, $p = .035$.

An examination of the scores of the six students who presented an inconsistent epistemic perspective (absolutist in the chocolate task and evaluativist in the fish farms task) reveals that their scores were closer to the scores of the consistent evaluativists than to those of the consistent absolutists, although lower than the consistent evaluativists (see Table 6). We reran the MANOVA without the inconsistent students and found the same effects but with somewhat larger effect sizes (epistemic perspective, $F(1,30) = 6.71$, $p = .015$, $\eta^2 = 0.18$, strategy, Wilks' $\Lambda = 0.83$, $F(1,30) = 6.26$, $p = .018$, $\eta^2 = 0.17$, interaction between epistemic perspective and strategy, Wilks' $\Lambda = 0.78$, $F(1,30) = 8.49$, $p = .007$, $\eta^2 = 0.22$, task type, Wilks' $\Lambda = 0.89$, $F(1,30) = 3.62$, $p = .067$, $\eta^2 = 0.11$, interaction between task and epistemic perspective, Wilks' $\Lambda = 0.88$, $F(1,30) = 4.30$, $p = .047$, $\eta^2 = 0.13$). Subsequent t-tests excluding the inconsistent students also gave similar results with one exception: In the evaluation strategy there was no longer a significant difference between tasks among the evaluativists, $t(11) = -1.90$, $p = .084$. The consistent evaluativists performed somewhat better in the chocolate task than the inconsistent students; therefore, excluding the inconsistent students decreased the difference between tasks in the evaluation strategy (see Table 6).

TABLE 6
Scores of Students with Inconsistent and Consistent Evaluativist Perspectives

Strategy	Task	Inconsistent Evaluativist Perspective (n = 6) M (SD)	Consistent Evaluativist Perspective (n = 12) M (SD)
Evaluation (0–12)	Chocolate	4.75 (1.89)	4.92 (2.98)
	Fish farms	6.64 (3.54)	6.92 (4.07)
Integration (0–12)	Chocolate	6.11 (2.36)	7.22 (2.24)
	Fish farms	7.67 (3.34)	9.45 (2.17)

DISCUSSION

Epistemic Thinking and Online Learning

The aim of our study was to characterize students' epistemic thinking during online learning and to examine whether or not it was related to students' online learning strategies. Our results confirm observations made by Hofer (2004) and Mason and colleagues (Mason & Boldrin, 2008; Mason et al., 2010a, 2010b) that epistemic thinking is activated at multiple points during online learning. We focused on two specific online learning strategies, evaluation and integration of multiple online sources, and attempted to demonstrate the "practical epistemologies" students possess concerning these strategies (Sandoval, 2005). In regard to both strategies, we found students' epistemic metacognitive knowledge to be correlated with their epistemic cognition: Students with greater knowledge of evaluation criteria and evaluation strategies evaluated websites more frequently and meaningfully. Students with higher awareness of possible differences between online accounts and the need to construct knowledge by integrating different perspectives were more likely to note differences among websites' points of view, compare them, and construct an argument based on multiple online sources.

Tsai (2004) suggests that the relation between personal epistemology and online learning should be viewed as bi-directional. On the one hand, sophisticated personal epistemology may promote students' online learning processes; on the other, the nature of online information prompts students to reflect on the epistemic nature of knowledge and may enhance the development of sophisticated personal epistemology. We believe that the bi-directional nature of epistemic thinking and online learning is also supported by our data, as we have tried to demonstrate with the analysis of Sivan's and Neta's protocols. For example, students' epistemic metacognitive knowledge may prompt them to examine a website's credibility or to seek out and compare multiple sites. At the same time, the diverse and sometimes contradictory nature of online claims may cause students to reflect on, develop, and elaborate their epistemic thinking.

Evaluating the Trustworthiness of Online Sources.   Regarding the website evaluation strategy, students' performance was on the whole quite low. On average, students evaluated the trustworthiness of only 39% of the websites they read. Students' EMKP concerning website evaluation was also lacking; only 52% of the students mentioned criteria relating to trustworthiness. Students' EMKS concerning website evaluation was low as well. The majority of students could not describe how they would evaluate a website's trustworthiness, and only a few students mentioned examination of scientific evidence or corroboration as strategies for evaluating source reliability. These results are consistent with the findings of previous studies that students encounter many difficulties in written and online source evaluation and that intervention is needed in order to help students develop source evaluation inclinations and skills (Brand-Gruwel & Stadtler, 2011; Brem et al., 2001; Britt & Aglinskas, 2002; Kuiper et al., 2005; Stadtler & Bromme, 2008; Walraven et al., 2008; Wiley et al., 2009). Contrary to our expectations, we failed to find significant differences between absolutists and evaluativists in the website evaluation strategy. We did find, however, that evaluativists exhibited somewhat higher awareness of source perspective and bias, especially on the metacognitive level.

There are several possible explanations for the lack of difference between absolutists and evaluativists in website evaluation. First, it should be noted that all students found it quite

difficult to evaluate the trustworthiness of online sources and were, on the whole, not always motivated to do so. Therefore, the similarity between absolutists and evaluativists could be attributed to low levels of competence in website evaluation. A second possible interpretation of these results would challenge Kuhn's developmental model. Kuhn and colleagues view epistemic understanding as developing in an integrative fashion (Kuhn et al., 2000). This position has been a point of much contention in the personal epistemology literature. An important line of research, starting with Schommer (1990), has claimed that personal epistemology is multidimensional and that epistemic beliefs may develop more or less independently. Critics holding this view could suggest that Kuhn's epistemic perspectives, specifically when assessed with the help of the "Can both be right?" question, do not capture the justification of the knowledge dimension well enough and that there is a need for multidimensional measures that assess justification more specifically. We believe that there is a strong case for viewing epistemic dimensions as interrelated but that better measures are indeed needed in order to capture the multidimensional nature of epistemic thinking within a developmental framework (see, e.g., Greene et al., 2008).

However, further reflection on the justification dimension, in light of Kuhn's theoretical model, may reveal that our results are not as surprising as they might seem at first. Kuhn and colleagues point out that both absolutists and evaluativists recognize a need for critical thinking (Kuhn et al., 2000). The difference between them is that absolutists view critical thinking as a tool for determining truth or falsehood of facts, whereas evaluativists see critical thinking as a tool for promoting sound judgments and enhancing understanding. Therefore, it should perhaps not be surprising that absolutists and evaluativists are equally inclined to examine online sources critically. The difference between them may lie instead in their evaluation and justification *goals*. The justification dimension is usually described as ranging from justification based on authority or personal opinion to justification based on reasoning and evaluation of evidence (Hofer & Pintrich, 1997). It may be necessary to rethink this range and look more closely at justification goals, with justification as a tool for choosing between right and wrong at one end and justification as a tool for evaluating different perspectives at the other. Our finding that evaluativists, in certain cases, were indeed more aware of bias and perspective as evaluation criteria may lend some initial support for this suggestion.

Critically Integrating Multiple Online Sources.   Students' epistemic cognition in the website integration strategy was measured using several indicators: identifying multiple points of view, making comparisons between websites, and using multiple websites to construct an argument. Evaluativists outperformed the absolutists in all of these indicators: They identified websites' points of view more often, made more comparisons between sites, and based their final arguments on a larger number of sites. These differences on the cognitive level were mirrored at the metacognitive level. Evaluativists were more likely to view knowledge as constructed from multiple sources and were more aware of differences in perspective between sources. As for the metastrategic aspect, evaluativists were much more likely than absolutists to describe integration as a strategy for negotiating conflicting sources.

These findings are consistent with results from studies by Bråten, Strømsø, and colleagues demonstrating that epistemic thinking plays an important role in integration of multiple documents (Bråten et al., 2011; Bråten & Strømsø, 2006, 2010; Bråten, Strømsø, & Britt, 2009; Bråten et al., 2008; Strømsø et al., 2008). Bråten, Strømsø, and colleagues have conducted their studies

among high school and university students, using offline documents, and have operationalized personal epistemology according to an epistemic beliefs framework. Our findings extend their observations to a younger age group (sixth graders), to different types of documents (authentic online sources) and, most interestingly, to a different approach to the study of epistemic thinking based on Kuhn's developmental model. We believe this congruence may indicate the strength of the relation between personal epistemology and integration of multiple sources: Student views of knowledge as constructed, complex, and developing appear to be central to the ability to integrate multiple documents, offline and online, in meaningful ways.

The role of knowledge justification in integration of multiple sources deserves further attention. In our study, although the evaluativists integrated multiple perspectives better than absolutists, this was largely due to greater awareness of the constructed and complex nature of knowledge and, usually, not to better understanding of knowledge justification methods, such as corroboration or use of scientific evidence. Students' understanding of corroboration left much to be desired. Corroboration was often understood by the students as checking out who agrees with whom and using agreement as an almost automatic indicator of reliability. The validity of the product knowledge integration requires sophisticated use of justification since different perspectives may entail different methods of justification. However, students appear to need much greater experience and training in order to evaluate different perspectives successfully when integrating multiple sources. This topic might be an interesting area for further research.

The Role of Epistemic Metacognitive Knowledge in Students' Online Inquiry Strategies

In this study we defined and operationalized epistemic thinking as a multifaceted construct that has both cognitive and metacognitive facets. Specifically, we examined the relation between students' epistemic cognition and their epistemic metacognitive knowledge (EMK). Our findings suggest that higher levels of source evaluation and integration are correlated with increased EMK regarding evaluation and integration. We propose that the relation between epistemic cognition and EMK is interactive and bi-directional. EMK may guide epistemic cognition through criteria, standards, and rules that shape learning behavior; however, epistemic cognition also provides inputs that serve as a foundation for forming EMK through reflective processes. It is difficult, for instance, to form epistemic metacognitive knowledge about inquiry strategies without engaging in these strategies.

The relation between epistemic cognition and EMK raises several questions that present directions for future research: How is the development of epistemic cognition related to the development of EMK? Is EMK a necessary condition for reaching high levels of epistemic cognition? Can an instructional intervention that focuses on developing students' EMK help them to develop more complex epistemic strategies? And if so, how?

Previous studies of students' epistemic metacognition have almost always focused on epistemic metacognitive knowledge about persons (EMKP). We would like to suggest that epistemic metacognitive knowledge about strategies and tasks (EMKS) is an important aspect of epistemic metacognition and a crucial link between students' EMKP about the nature of knowledge and knowing and how they go about creating and justifying knowledge. For example, a student may realize that there are differences in perspective between websites concerning certain topics but may not have the appropriate EMKS about how to integrate information from websites with

different perspectives in order to form an integrated understanding. Students not only need to have sophisticated views regarding the nature of knowledge and knowing but also need to be familiar with equally sophisticated strategies for constructing and justifying knowledge.

This suggestion has important educational implications. If we wish to foster complex epistemic thinking with the aim of improving students' abilities to construct knowledge, it is worthwhile to help them explicitly recognize the connections between their understanding of the nature of knowledge and knowledge construction strategies. Understanding the nature of knowledge and the development of knowing strategies may be seen as complementary goals that should be fostered in tandem. Studies have demonstrated that explicit instruction of metastrategic knowledge helps significantly to enhance students' scientific inquiry strategies, especially among lower-achieving students (e.g., White & Frederiksen, 1998; Zohar & Ben David, 2008). Our study of students' EMKS is still preliminary and requires elaboration and validation through the examination of their EMKS in other contexts and settings. Nevertheless, our results suggest that it is likely to be a fruitful and interesting area of research.

Interpreting Variability in Epistemic Thinking

The results of this study demonstrate that variability is present at all the levels of epistemic thinking. At the cognitive level, students applied a wide range of strategies, choosing among them according to their perceptions of task goals, conditions, and difficulty. For example, students had access to varied website evaluation criteria that were applied selectively. This variability was even more pronounced at the metacognitive level of students' epistemic thinking. Thus students described many strategies for dealing with conflicting online sources, each student usually describing more than one strategy, with strategies ranging from appeal to authority to the reasoned evaluation of contrasting arguments. There was also evident variability between tasks. The fish farms task was a context that elicited a greater degree of evaluativist reasoning than the chocolate task context.

It is possible to interpret this data by viewing differences in personal epistemology in terms of frequency distributions rather than dichotomies. Schommer has pointed that people may hold several epistemological beliefs at the same time, the difference between them being which beliefs are more dominant (Schommer-Aikins, 2002). King and Kitchener (2004) also noted that the epistemic reflection of the majority of participants in their studies could be ascribed to more than one level and suggested that the development of reflective thinking is better characterized as "a series of uneven, overlapping waves, where usage of given stage assumptions rises and falls in different proportions over time" (p. 10).

If we view the range of strategies used and described by the absolutists and the evaluativists in our study as snapshots of two points along a developmental trajectory, what we see is indeed a shift in frequency distribution. This was most apparent in the integration strategy, where differences between absolutists and evaluativists emerged most clearly. Absolutists and evaluativists described an overlapping range of strategies, but evaluativists mentioned recourse to authority somewhat less often and the evaluation and integration of multiple perspectives much more often (see Figure 5).

Furthermore, the evaluativists in our study did not abandon simple strategies that could be applied with ease and speed, and they turned to more effortful evaluation and integration when

they felt compelled to do so by task conditions. This may be one of the reasons for the performance of evaluativists in the fish farms task being significantly better than in the chocolate task. In the fish farms task the contradictions between websites could not be avoided or explained away easily. This type of task context motivated the evaluativists to rise to the challenge of creating an interpretation that would enable them to understand the contradictions. The chocolate task, however, is an example of a context that did not elicit similar strategies, perhaps because the contradictions were more easily avoided.

This view of the development of epistemic thinking ties in with recent suggestions that the key difference between learners with "sophisticated" beliefs and "naïve" beliefs is that learners with "sophisticated" beliefs can more flexibly adapt their learning strategies or epistemic judgments to task contexts and demands (Bromme et al., 2008; Elby & Hammer, 2001; Pieschl et al., 2008). Students with more "sophisticated" epistemologies may have more strategies at their disposal and exhibit a greater tendency to apply complex strategies when they are called for by the task context, but there is no reason to expect them to apply complex strategies all the time.

Limitations of the Study

Several limitations should be considered when evaluating the results of this study. First, our sample size was small and does not represent the broad student population. For example, the participants had high access to computers and high self-efficacy in using the Internet; they were also volunteers and, therefore, probably characterized by higher than average motivation for online learning. As a result, their online learning strategies may have been better than average. Second, we do not have data regarding the participants' cognitive abilities and cannot rule out the possibility that the evaluativists in our study had higher cognitive abilities than the absolutists. However, the finding that the evaluativists did not always outperform the absolutists makes this possibility less likely. In addition, several studies that measured both personal epistemology and cognitive ability suggest that these are two separate constructs (Klaczynski & Robinson, 2000; Trautwein & Lüdtke, 2007a; Weinstock et al., 2006). Third, our results relate to specific task contexts that provide just two possible examples of online learning settings. More complex and lengthier instructional designs, or designs that take into account social interaction, could yield different results. Fourth, our use of authentic websites and open Google search did not enable us to control myriad source characteristics, such as text length, clarity, difficulty, organization, design, authorship, trustworthiness and more—all of which have been shown to affect student learning. However, the use of such "messy" sources is typical of school assignments in which students are asked to search the Web for information. Fifth, in our study we met the students at only two, relatively close, points in time. Therefore, our research cannot provide information regarding variability and change in students' epistemic thinking across multiple contexts and over time. These limitations raise several possible directions for future research: extending the study to participants with different backgrounds, exploring additional task contexts, and examining the role of additional variables such as cognitive ability or Internet self-efficacy.

Educational Implications

Our study suggests that inquiry learning activities, and specifically online activities that present complex and open-ended questions, create opportunities for evaluativist epistemic thinking. The

advantage of the Internet in this respect is the immediate access it allows to multiple sources of diverse types and perspectives with current and authentic educational relevance. However, not all students may benefit from such tasks to the same extent. Students with absolutist epistemologies may miss the point of such tasks by ignoring multiple perspectives or by opting for a simple choice among them based on authority, plausibility, or a technical type of corroboration.

An explicit educational intervention designed to foster students' metacognitive awareness of the nature of knowledge and knowing online may help to promote students' strategies for online knowledge construction. This conjecture has yet to be examined empirically, and we hope that it will be as the field of personal epistemology moves into educational practice. As that happens, it would be worthwhile to pay more attention to the metastrategic aspects of epistemic metacognition and to help students relate their understandings of knowledge and knowing to the how, when, and why of knowing strategies. Students' understanding of the nature of knowledge in their domain of study and their awareness of the ways in which knowledge is constructed and justified in that domain may be developed in conjunction, through explicit instruction. For example, students need not only to be aware of the motivated nature of a great deal of online knowledge; they also need to learn how to identify motives and perspectives and how to counterbalance information by seeking out multiple perspectives and evaluating them.

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APPENDIX A: THINK-ALOUD PROMPTS AND INTERVIEW QUESTIONS

Think-Aloud Prompts

- After entering the website: Why did you enter this website?
- After at least 30 seconds in the website: What is your opinion about this website? Why is that your opinion?
- During pauses in the think-aloud commentary:
  - What are you thinking about now? Why?
  - What are you doing now? Why?
- After leaving the website: Why did you leave the website?

Interview Questions

- What is your answer to the question "Is chocolate healthy?"/"Do the fish farms in the Gulf of Eilat harm the coral reefs?"
- Why is that the answer?
- How do you know that this is the right answer?
- Can there be a single website with the right answer to this question?
- If yes, what kind of website would it be? If not, why?
- In your opinion, were the websites you entered good? Why?
- What is a good website?
- How can you know if a website is good?
- What would you do if you found two websites that make opposite claims about this question?
- If two websites make opposite claims about the question ". . . .," can only one site be right or could both be somewhat right?
  - If students say that only one can be right: Why? How can you tell which one is right?
  - If students say that both can be somewhat right: Why? Could one of the websites be more right than the other, or are they both equally right?
    - If students say that one cannot be more right than the other: Why?
    - If students say that one can be more right than the other: Why? How can you tell which one is more right?

APPENDIX B: CODING AND SCORING EPISTEMIC THINKING

Evaluation of Website Trustworthiness Strategy

Epistemic cognition (0–6 points).   The assessment of students' epistemic cognition in the evaluation strategy was based on their think-aloud protocols. We identified several levels of evaluation criteria used by the students and scored them according to their relative merit as criteria for evaluating website trustworthiness (Brem et al., 2001; Britt & Aglinskas, 2002; Wiley et al., 2009). We gave an evaluation score to each website the students read based on their best evaluation criterion and, subsequently, calculated an average evaluation score for the websites the students read (see Table A1).

EMKP (0–6 points).   Students' EMKP concerning evaluation of online sources was examined based on the explicit website evaluation criteria they described in the follow-up interview. Our questions asked in general about the qualities of a "good website." We specifically refrained from mentioning reliability or trustworthiness in our questions in order to see if the students would raise these issues spontaneously. We identified all of the website evaluation criteria mentioned by the students and gave each criterion a score on a range of 0–6 based on its relative merit for evaluating source trustworthiness, as explained earlier (see Table A1). When students described multiple criteria, their score was based on their best response.

EMKS (0–6 points).   Students' EMKS concerning strategies of website evaluation was assessed with the help of the interview question: "How can you know if a website is good?" Each recurring strategy was scored on a range of 0–6 based on its relative merit for evaluating website trustworthiness (see Table A1). When students described multiple strategies, their score was based on their best response.

Integration of Multiple Online Sources Strategy

Epistemic cognition (0–6 points).   Students' epistemic cognition score in the integration strategy was based on three indicators: (a) identification of website points of view, (b) comparison of websites, and (c) the use of multiple websites to construct an argument in response to the inquiry question. The choice of indicators was based on the literature regarding integration of multiple documents (e.g., Bråten et al., 2011; Rouet, 2006) and on the data that was consistently available in the participants' protocols. Each of the indicators was scored on a range of 0–6. The total epistemic cognition score was an average of all three indicators:

(a) *Identification of website points of view (0–6 points).* We assigned 2 points for each website point of view that the students identified correctly.

(b) *Comparison of websites (0–6 points).* Students got 0 points if they did not compare the websites they read, or if they compared only surface criteria, such as design or readability, 3 points for comparing specific content items across websites, and 6 points

TABLE A1
Codes and Scores for the Evaluation of Website Trustworthiness Strategy

Epistemic Facet	Data Sources	Codes	Scores
Epistemic Cognition (0–6 points*)	Students think-aloud reflections during the task	• Assesses content and form only	0 points
		• Notes source characteristics	2 points
		• Evaluates source trustworthiness based on:	
		○ authority,	4 points
		○ expertise,	6 points
		○ scientific evidence or research,	6 points
		○ perspective or bias.	6 points
Epistemic Metacognitive Knowledge about Persons (EMKP) (0–6 points**)	Interview questions: • In your opinion, were the websites you entered good? Why? • What is a good website?	Evaluation criteria:	
		• Relevance, usability, design, amount of information	0 points
		• Popularity, familiarity, type of website	2 points
		• Trustworthiness based on authority	4 points
		• Trustworthiness based on expertise, scientific evidence or research, or perspective/bias	6 points
Epistemic Metacognitive Knowledge about Strategies and Tasks (EMKS) (0–6 points**)	Interview question: • How can you know if a website is good?	Evaluation strategies:	
		• Examining relevance	0 points
		• Assessing usability or design	0 points
		• Checking if information is sufficient	0 points
		• Relying on popularity, recommendations, or familiarity	2 points
		• Evaluating trustworthiness by examining content	6 points
		• Evaluating trustworthiness through corroboration with other websites	6 points

*A score was calculated for each website that the students read based on their highest evaluation level of the site on a range of 0–6. The overall score was based on an average of the website evaluation scores of the websites the students read. Students read three websites in the fish farms task and an average of two websites in the chocolate task.

**Students' score was based on their best response.

for comparing website trustworthiness or website points of view. Their overall score was based on their best performance.

(c) ***Use of multiple websites to construct an argument (0–6).*** Immediately after completing the search, students were asked to state their responses to the inquiry questions and explain their answers. We examined both the reasons they provided and their justifications and counted the number of websites on which their answers relied. It was relatively simple to trace the reasons to the corresponding websites because each website contained different information. Students got 2 points for each website used in their argument, up to a maximum score of 6 points.

EMKP (0–6 points).   Students' EMKP about website integration was assessed according to their answers to the interview questions: "Can there be a single website with the right answer to this question? If yes, what kind of website would it be? If not, why?" These questions were based on the observation that many students assume the answer is "out there" in a single website and, therefore, see little need for integrating multiple websites in order to construct an answer (Kuiper et al., 2005; Wallace et al., 2000). Students who said that there can be a single website with an answer to the question got 0 points. Students who said that an answer should be based on multiple websites got 2 points. We also gave points for the reasons they provided for their answers. Students who based their reasons on the amount of information found in the website(s) received no additional points because this type of answer indicates an accumulative view of information seeking that does not take into account the need to construct and integrate knowledge. Students who based their reasons on the trustworthiness of the website(s) received an additional 2 points because their reply indicated an awareness that websites differ in their reliability. Students who based their reasons on the existence of multiple perspectives received an additional 4 points because they viewed knowledge integration not just as a means for increasing reliability but also for accounting for the complex and multifarious nature of knowledge. When students gave multiple reasons, they could get a maximum of 4 additional points.

EMKS (0–6 points).   In order to investigate students' EMKS concerning the integration of multiple sources, we asked them: "What would you do if you found two websites that made opposite claims about this question?" Students who said they would choose a single website received 0 points, whereas those who said they would consider both websites received 2 points. We assigned additional points based on the strategies described by the students for integrating multiple websites. When students said they would choose one answer based on plausibility or authority, they received no additional points because this type of strategy avoids knowledge integration by opting for a simple choice among answers. However, when students said they would choose among answers based on their justification or through corroboration of multiple websites, they received an additional 2 points. Students who described strategies for integrating multiple perspectives received an additional 4 points. When students gave multiple reasons, they could get a maximum of 4 additional points (see Table A2).

TABLE A2

Codes and Scores for the Integration of Multiple Online Sources Strategy

Epistemic Facet	Data Sources	Codes	Scores

Epistemic Cognition (0–6 points*)	Students think-aloud reflections during the task and the interview questions:
	• What is your answer to the question?
	• Why is that the answer?
	• How do you know that this is the right answer?
		• Identifies website points of view correctly
		• Website comparison:
		  ○ No comparison or surface comparison
		  ○ Compares content
		  ○ Compares points of view or trustworthiness
		• Bases argument on multiple websites
			2 points per each correct point of view
			
			0 points
			3 points
			6 points
			2 points per each website in argument

Epistemic Metacognitive Knowledge about Persons (EMKP) (0–6 points**)	Interview questions:
	• Can there be a single website with the right answer to this question?
	• If yes, what kind of website would it be? If not, why?
		• Views of knowledge as constructed from multiple sources:
		  ○ Answer can be found in a single website
		  ○ Answer should be based on multiple websites
		• Additional points for reasons for the above positions:
		  ○ Amount of information
		  ○ Trustworthiness
		  ○ Multiple perspectives
			0 points
			2 points
			
			0 points
			2 points
			4 points

Epistemic Metacognitive Knowledge about Strategies and Tasks (EMKS) (0–6 points**)	Interview question:
	• What would you do if you found two websites that make opposite claims about this question?
		• Strategies for choosing websites:
		  ○ Choosing a single website
		  ○ Considering more than one website
		• Additional points for strategies for dealing with multiple websites:
		  ○ Choosing among answers based on authority or plausibility
		  ○ Choosing among answers based on justification or corroboration
		  ○ Integrating multiple perspectives
			0 points
			2 points
			
			0 points
			2 points
			
			4 points

*The score was based on an average of the three indicators.
**Students' score was based on their best response.