Epistemological Understanding as a Metacognitive Process: Thinking Aloud During Online Searching
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Personal epistemology has typically been conceptualized in one of two primary ways: as a cognitive developmental process or as a system of beliefs. The approach that is elaborated here is to conceive of epistemological understanding as a metacognitive process that activates epistemic theories, a multidimensional set of interrelated beliefs about knowledge and knowing. Building on the work of Flavell (1979), K. S. Kitchener (1983), and Kuhn (1999b), this article describes the rationale for conceptualizing epistemological awareness at the metacognitive level, delineates the nature of this construct, and describes how this directs methodological choices for research. This is discussed in light of a recent study of students’ online searching for a simulated science assignment, investigated through the use of think-aloud protocols. Exploring students’ thought processes during online searching allows examination of personal epistemology not as a decontextualized set of beliefs, but as an activated, situated aspect of cognition that influences the knowledge construction process.

Imagine that you have just learned that you have a medical condition about which you know very little. Will you accept your doctor’s prognosis as the final word on the matter, or will you seek to further your own understanding about the topic? If you choose to seek additional information, where will you go? Will you consult other medical personnel, confer with friends and relatives, examine journals or books, identify related Web sites? Do you pick up the phone, browse a library or bookstore, search for information online?

As you begin to construct working knowledge on a topic such as this, you are likely to be engaging in an array of metacognitive processes known to educational psychologists. You are likely to be monitoring your understanding of new terms, judging whether you comprehend what you encounter, and regulating your reading in response. You are also likely to be engaging in another level of metacognitive processes, not as well articulated by educational psychologists, those that involve epistemic monitoring and judgment. For example, as you build your own knowledge about a topic that is previously unfamiliar, how will you evaluate and assess the veracity of what you read and hear? Whose authority will you accept—and why? What evidence will you decide is acceptable justification for particular recommended choices of action? How certain are you that what you read is true, that it is supportable, that it can be believed? How will you reconcile your own experience with those of experts? When do you decide that you know enough and that your understanding is adequate? These latter concerns represent an illustrative sample of questions whose answers will be influenced by one’s personal theory of knowledge and knowing, or what has been called personal epistemology (Hofer, 2002).

I chose the above vignette for several reasons. First, the example is likely to be both common and vivid for most adults and illustrates that the nature of “personal epistemology” is not as esoteric as it may sound but rather is an aspect of metacognitive awareness that is often activated in the knowledge construction process. As such, it appears to be an important and underinvestigated aspect of learning, both in and out of school, and needs greater attention as an aspect of metacognition. Second, whether we make such epistemological assessments as we learn, and how we go about doing so, will have significant consequences—for example, in our health decisions, political choices and actions, and also in our scholarship, of course—and will contribute to the thoroughness, completeness, and legitimacy of our own knowledge. Third, most readers who imagined themselves in the vignette are likely to have identified computer searching as a part of the quest for additional knowledge. Individuals are increasingly likely to approach such questions that require learning about a new topic through a computer-based
search on the Internet, regardless of what other courses of action they may choose to follow. In academic contexts, online searching is often the routine manner in which students gather information in the process of constructing their understanding of a new topic for school tasks, such as research papers, group projects, and oral reports. Yet we have very little information about the epistemic nature of how individuals approach this process, a fairly private and unexamined aspect of learning.

Monitoring and evaluating the epistemic nature of what we observe, hear, and read as we construct our own knowledge occur not only in school, but also throughout life, and yet we may be doing little to prepare individuals for making the kind of informed judgments that the touted “knowledge explosion” demands. Such judgments are part of the construct of personal epistemology, which has been pursued through several substantive lines of inquiry, as the articles in this issue attest. However, the fragmented nature of our current approaches to investigating personal epistemology, divided by nomenclature and residing in various disciplinary camps, has not been beneficial to developing teacher understanding of the construct or designing interventions that are congruent with current approaches to lifelong learning. Thus we need to develop an overarching understanding of the processes involved.

Building on existing work by others as well as on current research I have been conducting, I describe an approach to exploring personal epistemology as a metacognitive process—as epistemic metacognition. This approach, one that is not mutually exclusive with the others but perhaps is an overarching link among them, has previously been described as epistemic cognition (K. S. Kitchener, 1983) or epistemological meta-knowing (Kuhn, 1999a, 1999b), each building on a broad conceptualization of metacognition that encompasses “knowing about knowing.” Most of the research carried out on metacognition, however, has focused more on “thinking about thinking.” Considering the epistemic aspects of metacognition as an important component of the process returns us to the more expansive understanding of the processes initially described (Flavell, 1979). Simultaneously, this expands our understanding of personal epistemology and locates it cognitively. What I hope to show with this approach to the concept is that this process of epistemic monitoring and evaluation not only occurs in addressing ill-structured problems (King & Kitchener, 1994) or in argumentation about complex problems (Kuhn, 1991), although it is indeed evoked by and essential to such tasks, but is also more commonly activated in the knowledge acquisition and construction process that takes place in everyday learning, both in and out of school.

In addition to clarifying and delineating the construct by locating it within a broader understanding of metacognition, I explain how this conceptualization enhances our understanding of the notion of epistemic theories and the dimensions that comprise such theories (Hofer, 2001; Hofer & Pintrich, 1997). Furthermore, this conceptualization suggests particular methodological choices, indicated by existing investigations of metacognition (Pintrich, Wolters, & Baxter, 2000). Accordingly, examples from recent research using think-aloud protocols to tap epistemic metacognition during students’ online searching are provided as an illustration of this approach. Exploring students’ thought processes during online searching allows us to examine personal epistemology not as a decontextualized set of beliefs, but as an activated, situated aspect of cognition that influences the knowledge building process. As the manner in which students access information has changed, we need to be aware of how individuals evaluate ideas, coordinate theory and evidence, and justify their knowledge assumptions, all aspects of epistemological thinking.

**PARADIGMATIC APPROACHES FOR EXPLORING PERSONAL EPISTEMOLOGY**

As elaborated in an earlier review of the literature (Hofer & Pintrich, 1997), personal epistemology has its origins in theories of cognitive development (Piaget, 1950) and studies of student intellectual development (Perry, 1970). Researchers who investigate personal epistemology are typically concerned with the beliefs and theories that individuals hold about knowledge and knowing. Educational psychologists have been particularly interested in how such theories of knowledge influence and are influenced by learning and education (Hofer, 2001). Historically, in the several decades of research on personal epistemology, the construct has most often been conceptualized in two ways: as a cognitive developmental process that proceeds in a patterned, developmental sequence (Baxter Magolda, 1992; King & Kitchener, 1994; Kuhn, 1991; Perry, 1970 1981), or as a system of beliefs (Schommer, 1990, 1994; Schraw, Bendixen, & Dunkle, 2002). More recent alternative approaches are to view personal epistemology as theory-like (Hofer & Pintrich) or as more fine-grained epistemological resources (Hammer & Elby, 2002). In the process of learning, such theories and resources are activated and engaged, in ways that are context dependent.

**Overview of Approaches**

**Epistemological development.** Those who view personal epistemology as a developmental progression (Baxter Magolda, 1992; Belenky, Clinchy, Goldberger, & Tarule, 1986; King & Kitchener, 1994; Kuhn, 1991; Perry, 1970) have suggested that individuals move through a developmental sequence that reflects an evolving ability to coordinate the subjective and objective aspects of knowing (Burr & Hofer, 2002; Kuhn & Weinstock, 2002). This trajectory typically moves from a dualistic and absolutist view of knowledge to a
multiplicitic stance, as the knower begins to acknowledge areas of uncertainty. A resulting period of extreme subjectivity appears to be resolved by the recognition that there are relative merits to particular views and that positions can be supported with evidence. Final stages in most models are characterized by the view that knowledge is actively constructed by the knower, thus providing a reconciliation of the objective and subjective aspects of knowing. From this viewpoint, knowledge is regarded as continuously evolving, and knowing is coordinated with justification.

Epistemological development is a distinct paradigmatic approach to investigating personal epistemology, with fundamental underlying assumptions about the constructivist, interactionist mechanisms of development; the relation to cognitive development; and the evolving relationships between the knower and the known. Particular methodological choices have followed. Within this tradition, most researchers investigating epistemological development have conducted interviews to assess individuals’ conceptions of knowledge and knowing and how these change over time; paper-and-pencil measures have been attempted but have been somewhat less fruitful measures (Wood, Kitchener, & Perlmutter, 1980). These methodological choices will be addressed in more detail later.

**Epistemological beliefs.** By contrast to the developmental models, Schommer (1990) suggested that personal epistemology can best be understood as a collection of beliefs about knowledge and learning, and that these beliefs might be more or less independent, rather than existing in integrated fashion and developing in a coordinated sequence. Other researchers have accepted these premises and pursued similar investigations and constructs, such as epistemic beliefs (Bendixen, 2002; Bendixen, Schraw, & Dunkle, 1998; Schraw et al., 2002). Researchers who adopt the paradigm of epistemological or epistemic beliefs have typically approached their investigation through questionnaires that seek level of agreement with particular items, typically measured on a Likert-type scale, rather than through interviews. (This has not exclusively been the case; e.g., see Bendixen). This is in accordance with a psychological model of beliefs as cognitive constructs accessible by the individual, consistent and stable enough to be measured in a decontextualized manner. The value of this approach to measurement has been that it has made it possible for educational psychologists to examine the relation between these beliefs and other academic constructs, and it is in this way that research on personal epistemology has become more familiar to readers of educational psychology journals. For example, epistemological and epistemic beliefs have been examined in relation to strategy use (Schommer, Crouse, & Rhodes, 1992), cognitive processing (Qian, 2000), conceptual change learning (Kardash & Howell, 2000), and moral reasoning (Bendixen et al.).

**Epistemological theories.** An alternative conception is that individual ideas about knowledge and knowing may be organized into theories. Epistemological theories also are viewed as explicitly multidimensional, but this conceptualization suggests that there is integration among an individual’s perspectives, which is more than a collection of independent beliefs (Hofer, 2001; Hofer & Pintrich, 1997). Compelling research from developmental models suggests coherent organization among epistemological perspectives, and there has been little competing evidence to suggest that these are unrelated propositions. We need more research, however, to examine the nature of the integration of beliefs into theory-like status. Such theories might be expected to operate not simply as a sum of beliefs, but rather as an organized way of knowing, both at the domain-general and domain-specific level; for example, a student might have a generalized theory of knowledge and also specific theories about knowledge in science versus knowledge in history. Epistemological theories have been assessed at the level of classroom investigations (Hofer, in press) as well as through self-report measures that are discipline specific (Hofer, 2000), and are envisioned as concepts that are activated and engaged during learning as an aspect of metacognition (Hofer, 2001).

Although epistemological beliefs and epistemological development have been explored as two distinct paradigmatic approaches to understanding personal epistemology, they are potentially compatible views, as beliefs, organized and structured as theories, might be expected to develop over time in somewhat predictably patterned ways. However, little research has been conducted to date to explore this more synthetic view, and current methodological approaches seem to limit such investigations, although new instruments may show promise in this regard (Kuhn, Cheney, & Weinstock, 2000).

**Epistemological resources.** An alternative ontological position on personal epistemology was provided by Hammer and Elby (2002), who posited a framework of epistemological resources, which are more fine grained and context specific than epistemological beliefs, and less stable or trait-like, and situated in educational contexts. Examinations of this construct exist in sociocultural settings, embedded in practice (Louca, Elby, Hammer, & Kagey, 2004). From this perspective, individuals have a host of epistemological resources available to them as learners, and the context determines what might be evoked; such an approach seems less sensitive to the cognitive developmental assumptions that underlie other models but more attuned to contextual variables.

Educational Implications of Paradigmatic Approaches

One of the important implications of the paradigmatic distinctions in the two dominant approaches is the relation between personal epistemology and education, driven by dif-
ferences in ontological and theoretical assumptions (Hofer, 2001). Those who have come to the study of personal epistemology as developmental psychologists or as educators, or from a student development perspective, have typically identified a course of development and examined how educational experiences enhance the progression toward advanced epistemological outcomes (e.g., reflective judgment, epistemological reflection, evaluativism, or more contextual ways of knowing, depending on the particular scheme of development). Such outcomes are often viewed as congruent with higher order thinking skills, for example. Thus, from this paradigm, personal epistemology is a developmental construct, and education influences this development. By contrast, most educational psychologists who have pursued research using the framework of epistemological beliefs view such beliefs as a feature of the individual—a trait-like aspect of individual differences. Accordingly, such researchers have been interested in how beliefs influence learning. From this paradigmatic approach, beliefs are viewed as predictors of outcome variables such as achievement, comprehension, and conceptual change.

The alternative perspective offered here is to view the outcome as the dynamic process of learning and knowledge building, influenced through the metacognitive monitoring of epistemological beliefs, resources, and theories. Furthermore, this view of personal epistemology as a metacognitive process permits the possibility of a more interactive conception, and one that is malleable, situated, and influenced by teacher, task, and learning environment.

Dimensions of Personal Epistemology

Regardless of the paradigmatic approach, personal epistemology appears to consist of specific dimensions that comprise individual understanding of knowledge and knowing. The concept of epistemological beliefs, for example, is an inherently multidimensional one, evident in the factorial approach to measurement, although, as noted, there is debate about the degree of coherence among the dimensions. Each of the various schemes of epistemological development encompass somewhat similar dimensions that are transformed in sequenced progressions. Epistemological theories, comprised through explicit review of the dimensions that appear consistently across the various schemes of both traditional paradigms (Hofer & Pintrich, 1997), consist of two main components that are viewed as congruent with the conventional definition of epistemology, a philosophical field concerned with the nature of knowledge and knowing. These two areas are the nature of knowledge (what one believes knowledge is), which includes the dimensions certainty of knowledge and simplicity of knowledge; and the nature or process of knowing (how one comes to know), which includes the dimensions source of knowledge and justification for knowing.

Certainty of knowledge concerns the degree to which one sees knowledge as fixed or more fluid, ranging from the perspective that absolute truth exists with certainty to the position that knowledge is tentative and evolving. In the developmental schemes, higher positions are marked by openness to new interpretation (King & Kitchener, 1994) and the possibility that one’s theories may be modified by genuine interchange (Kuhn, 1991). Simplicity of knowledge is generally viewed as a continuum ranging from knowledge as an accumulation of discrete, knowable facts to a higher level view of knowledge as highly interrelated concepts that are relative, contingent, and contextual (Schommer, 1990). Source of knowledge, as identified in most of the developmental models, refers to the relationship between knower and known and reflects a progression that moves from a view of knowledge as residing outside the self and transmitted from external authorities to a position of viewing oneself as an active constructor of meaning. Justification for knowing includes how individuals consider what makes a sufficient knowledge claim both in the evaluation and production of knowledge (Weinstock & Cronin, 2003). Developmentally, this dimension has been described as ranging from justification based on observation or authority (when knowledge is perceived as certain) or on the basis of what feels right (when knowledge is perceived as uncertain) to the use of rules of inquiry and the evaluation of expertise (King & Kitchener, 1994).

Although there are some schemes that also include beliefs about intelligence (Schommer, 1990) or learning (Baxter Magolda, 1992; Moore, 2002), for purposes of examining the metacognitive nature of epistemology, I will focus attention on the four dimensions identified as components of epistemological theories. Exploring the metacognitive nature of epistemology may also make it possible to get a better sense of how these dimensions operate together—as a “theory-like” conception would suggest—as well as how such beliefs are related to learning.

EPISTEMIC METACOGNITION AS AN EMERGING PARADIGM

Representing personal epistemology as an aspect of metacognition provides for an alternative paradigm, one that creates the possibility of integrating multiple perspectives of the construct. Conceptualizing the construct as a form of meta-knowing—a knowing about knowing, as suggested by K. S. Kitchener (1983)—makes it possible to see personal epistemology as a set of beliefs, organized into theories, operating at the metacognitive level. Such theories develop in interaction with the environment, are influenced by culture and education and other context variables, operate at both the domain-general and domain-specific level, are situated in practice, and are activated in context. They are called into play in encounters with new information, in the context of knowledge building, not only in solving challenging...
ill-structured problems but also in any other situation where competing knowledge claims vie for attention and resolution. These theories about knowledge and knowing also serve as goals, so that they have a motivational function as well, also evident at the metacognitive level. For example, if one believes knowledge is finite, then multiple sources of information might prove redundant and confusing; a search for competing truths is unnecessary, as is any attempt to resolve those that emerge. In this section I examine these claims and explain more about the paradigmatic implications of interpreting epistemic understanding as a metacognitive process.

Overview

As noted earlier, locating personal epistemology in the metacognitive realm is not new, was first articulated by K. S. Kitchener (1983), undergrads the 20-plus years of work on reflective judgment (King & Kitchener, 1994), and has been further developed and elaborated by Kuhn (1999a, 1999b, 2000a, 2000b). K. S. Kitchener described a three-level model of cognitive processing in which each level provides a foundation for the next: cognition, metacognition, and epistemic cognition. In this hierarchy of processing, the first level includes such tasks as computing, reading, and perceiving, and the second refers to the processes that permit knowledge about cognitive tasks, such as strategy use and monitoring. Epistemic cognition operates in conjunction with the first two levels and involves monitoring the epistemic nature of problem solving, including an awareness of the limits and certainty of knowing, and the criteria involved in the process of knowing. K.S. Kitchener suggested that epistemic cognition is particularly useful in solving ill-structured problems and that it emerges in late adolescence and continues to evolve during adult years.

A similar theoretical proposition regarding the metacognitive nature of epistemological understanding was posited by Kuhn (1999b), who proposed that “meta-knowing” encompasses any cognition that has cognition as its object. Meta-knowing includes three levels: metacognitive knowing, metastrategic knowing, and epistemological meta-knowing. Knowing about declarative knowledge (knowledge as product) is metacognitive knowing, and knowing about procedural knowing (knowledge as process) is classified as metastrategic knowing. The more abstract process of knowing about knowledge and knowing, either one’s own or another person’s, is epistemological meta-knowing.

Both schemes propose a hierarchal ordering of the epistemic aspects of metacognition, are described as cognitively advanced and abstract processes arising perhaps in late adolescence, and have been investigated through ill-structured problem solving (King & Kitchener, 1994), argumentation (Kuhn, 1991), and complex tasks such as juror reasoning (Kuhn, 2000a; Kuhn, Weinstock, & Flaton, 1994). The schemes obviously differ in some respects, such as terminology and the proposed cognitive hierarchy. In elaborating on this approach to the metacognitive nature of epistemological thinking, I want to address several interrelated issues: terminology, expansion of the context in which such metathinking is understood to occur, the notion of late adolescent origins, and the location of epistemic concerns within a familiar model of metacognition.

Terminology.

Epistemology as a philosophical enterprise is concerned with the origin, nature, limits, methods, and justification of human knowledge. Researchers in the field of “personal epistemology” have appropriated philosophical terms to describe psychological constructs, typically investigated in regard to educational settings, processes, and outcomes. Not surprisingly, this cross-disciplinary borrowing has resulted in ambiguity and lack of precision about terminology. Are epistemic beliefs (Schraw et al., 2002) and epistemological beliefs (Schommer, 1994), for example, different names for comparable constructs? Philosopher R. Kitchener (2002) pointed out that just as epistemology is a theory of knowledge, personal epistemology (or folk epistemology) is a personal theory about knowledge (the epistemic), and epistemic beliefs are beliefs about knowledge. According to R. Kitchener, the problem lies in terms such as epistemological beliefs (Schommer, 1994) or epistemological meta-knowing (Kuhn, et al., 2000), which would be viewed by philosophers as referring to beliefs or meta-knowing about epistemology, and not about knowledge, and so such terms may muddle our understanding of the constructs we aim to explore. R. Kitchener similarly addressed issues of cognition and knowledge, noting that cognitions are of weaker status than knowledge (what is truly known is weaker than what is merely represented), and that metaknowing differs in similar regard from metacognition. On these grounds, he dismissed the elevation of metaknowing as any cognition about cognition, as outlined by Kuhn (2000a). Accordingly, in the metacognitive model proposed here, I refer to “epistemic theories”—although described elsewhere as “epistemological theories” (Hofer & Pintrich, 1997)—and to the metacognitive employment of these theories as epistemic metacognition.

Age-related assumptions and ill-structured problem solving.

Although it is likely that sophisticated consideration of assumptions about knowledge and knowing develops late in adolescence or early adulthood (if at all), a broader reading of the developmental aspects of both metacognition and personal epistemology might suggest that these processes occur at earlier points, albeit with less well-reasoned premises. The stage models that begin with dualistic, absolutist views of knowledge, for example, indicate that this level represents an earlier form of epistemological understanding, rather than the absence of the process altogether. Similarly, the beliefs model posits that some students have less sophisticated beliefs than do others but does not suggest that at lower levels students are not thinking epistemologically at all. To hold the beliefs that
knowledge is certain and simple is still to hold an epistemic belief with its own set of consequences and implications for learning.

Presuming that the process of epistemic metacognition begins in late adolescence would fail to address how students make epistemic judgments (however poorly supported) in their resolution of competing claims and ill-structured problems in earlier years. Perhaps the ability to be metacognitive includes the ability to consider epistemological questions, even if they are resolved at the lowest levels of the developmental hierarchy. For example, even the youngest student, upon hearing a teacher make a claim that contradicts a statement of a parent—for example, about whether dinosaurs inhabited Earth at the same time as humans—may reflect on this conflict and then decide whom to believe. This would suggest a metacognitive reflection concerning which authority has higher credence, which would be considered an aspect of epistemological processes in any of the existing schemes of personal epistemology.

This claim challenges the age-related assumptions that epistemic metacognition begins in adolescence, as well as the need for locating epistemic meta-knowing at a level beyond metacognition. It would seem that students who are developmentally capable of metacognitive assessments of the typical sort (“Am I understanding this?”) would also be capable of epistemic assessments (“Do I believe this?”), for example, even if their judgments were simple ones (“The teacher can’t be right, because Dad is right”). The student whose resolution of competing claims is premised on the belief that only one of the claims can possibly be correct has metacognitively employed an epistemological assumption, and research indicates that this type of thinking is common among younger students (Chandler, Hallett, & Sokol, 2002; Kuhn, 1999a; Mansfield & Clinchy, 1985).

Similarly, this also indicates that epistemological issues are salient in everyday learning, not just in the resolution of complex, ill-structured problems. Individuals are often confronted with contradictory claims or exposed to multiple interpretations of a topic and must make choices about authority and evidence, whether this is as simple as outright rejection or whether it involves active monitoring, assessment, a search for alternatives, and a considered reconciliation of viewpoints. Although the epistemological aspects of metacognition have typically been identified by researchers through the use of ill-structured problems and undoubtedly merit clearer identification in such situations, this does not mean that this metacognitive process is not operative in broader contexts, and we have good reasons to suspect that it is.

Locating Epistemological Awareness within a Model of Metacognition

Research on metacognition suggests that it is multidimensional (Schraw, 1998) and is often viewed as a three-component process, although these components may vary among models (Flavell, 1979; Pintrich et al., 2000; Schraw & Moshman, 1995). Within a three-component model of metacognition, where might we then locate epistemic metacognition? In one model of metacognition (Pintrich et al.), offered here as a theoretical starting point, the components are (a) metacognitive knowledge, (b) metacognitive judgments and monitoring, and (c) self-regulation and control of cognition and learning. The metacognitive knowledge component is the most static and includes one’s knowledge about cognition and strategies, as well as knowledge of task variables that influence cognition, and knowledge of self as a learner or thinker. Metacognitive judgments and monitoring are more process-oriented and involve such aspects as judging task difficulty, monitoring one’s comprehension and learning, and assessing confidence. Self-regulation and control of cognition refer to planning, strategy selection, allocation of resources, and volitional control. If we expand the conception of metacognition to include not only “thinking about thinking” but also “knowing about knowing” as suggested by K. S. Kitchener (1983), we can utilize this three-component framework as a starting point for a broader reconceptualization. (See Table 1.)

This makes it possible to see how the four dimensions of epistemic theories function and how they might be located within the model, thus allowing us to better understand their nature, function, and interrelationship. The first component of the existing model—metacognitive knowledge—would be expanded to include the two epistemological dimensions identified as aspects of beliefs about the nature of knowledge: certainty of knowledge and simplicity of knowledge. Parallel to knowledge of strategies, tasks, and beliefs, these beliefs about knowledge would likely develop concomitantly; beliefs about the simplicity of knowledge have been shown to have a moderate correlation with strategy use (Schommer et al., 1992). This component of the model might be further expanded to include not just “self as learner or thinker” (although Pintrich et al. (2000) view these more as motivational self-knowledge) but “self as knower.” This could include such constructs as need for cognition (Cacioppo & Petty, 1982; Cacioppo, Petty, Feinstein, & Jarvis, 1996) and need for epistemic closure (Kruglanski, 1980), which have been categorized as “epistemological dispositions” (Klaczynski, 2000) and explored in regard to epistemological understanding.

Within the second component—metacognitive judgments and monitoring—the processes described in the existing model (Pintrich et al., 2000) are those that lead the individual immersed in learning and comprehension tasks to metacognitively reflect on such questions as “Do I know this?” Related epistemological processes, by contrast, engage the learner in asking “How do I know this?” Thus, the two previously described dimensions related to the nature of knowing—that is, source of knowledge and justification for knowing—seem well placed here. As individuals read, listen, experience, and learn, they are monitoring and judging
Expanding Metacognition to Encompass Epistemic Processes

<table>
<thead>
<tr>
<th>Metacognitive knowledge</th>
<th>Metacognitive judgments and monitoring</th>
<th>Self-regulation and control of cognition (e.g., “Do I need to read this again?”)</th>
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</thead>
<tbody>
<tr>
<td>Knowledge about cognition and strategies, tasks and contexts, self as learner or thinker</td>
<td>Monitoring comprehension and learning, judging task difficulty (e.g., “Do I understand this?”)</td>
<td>“Do I need to read this again?”</td>
</tr>
<tr>
<td>Beliefs about the Nature of Knowledge</td>
<td>Evaluating Source of Knowledge: “How do I know this?”, “How does this fit with my own experience?”</td>
<td>Regulating cognition during knowledge construction</td>
</tr>
<tr>
<td>Certainty of Knowledge: Tacit beliefs about whether knowledge is certain or tentative and evolving</td>
<td>Determining Justification for Knowing: “Do I judge this to be credible?”, “Is there evidence to support this claim?”, “Can I reconcile theory and evidence?”</td>
<td>Self regulation of knowing as affected by volition, interest, motivation, thinking dispositions, intellectual values, and beliefs: “Do I know what I need to know or do I need to know more?”, “How will I go about this?”</td>
</tr>
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</table>

These regulatory aspects of knowing described earlier are captured in the third component of the model—self-regulation and control of cognition—which expands upon the regulation of cognition in the knowledge construction process. This includes such constructs as volition, interest, motivation, thinking dispositions, intellectual values, and beliefs that may come into play as one is building an understanding of a topic, as one metacognitively ponders one’s own knowing and determines whether and how to proceed. (“Do I know what I need/want to know, or do I need to know more?” “How will I go about this?”) This component acknowledges the significance of intentionality in epistemic metacognition.

What is needed is further investigation of the metacognitive nature of these processes and empirical tests of these claims. Reconceptualizing personal epistemology as epistemic metacognition permits new lines of inquiry and calls for particular methodological approaches that are consistent with this paradigm.

METHODOLOGICAL IMPLICATIONS OF PARADIGMATIC APPROACHES

As noted earlier, particular paradigmatic approaches to the exploration of personal epistemology have guided methodological choices. One facet of research on personal epistemology (e.g., Perry, 1970; Baxter Magolda, 1992) has been built on interview methodology, grounded in a phenomenological approach. Such researchers posit students as active meaning makers whose understanding of knowledge and knowing are transformed through their interaction with the environment, thus they want to capture that without prior assumptions about the patterns that such meaning might take. Although some researchers might argue that this type of research is necessary only in the early phases of an investigation until categories are clear and other instruments
can be devised, others argue that it is not just a step in the research process but is representative of fundamental underlying assumptions (see Baxter Magolda, 2004).

Others have conducted more structured interviews based on ill-structured problems, followed by specific follow-up questions designed to elicit reasoned reflection and underlying assumptions. King and Kitchener (1994), for example, provided problems that present conflicting points of view on such topics as who built the pyramids or the safety of food additives and then probed with questions such as “Can you ever know for sure that your point of view is correct?” Trained raters assigned a level of reflective judgment to the responses. Similarly, Kuhn (1991) conducted studies of argumentation by asking students to address such questions as “What causes criminals to return to crime after they’re released?” followed by a set of questions, such as “Do experts know for sure what causes this?” and responses were assigned an epistemological level. Kuhn also utilized other approaches that enable assignment of epistemological levels, such as probing juror reasoning and asking for responses to multiple accounts of fictitious wars (Kuhn & Weinstock, 2002). The underlying assumption in all these approaches is that epistemological thinking occurs in the process of resolving competing claims to problems for which there may be no clear-cut right answer.

Those working with epistemological beliefs, epistemic beliefs, or epistemological theories have most often used survey methods for assessing individual conceptions of knowledge and knowing. Measuring beliefs on a Likert-type scale as a means of assessing degree of agreement with conceptions of knowledge and knowing has been particularly beneficial in large-scale assessments. The instrument most commonly in use is the Epistemological Beliefs Questionnaire (Schommer, 1990), but there have also been attempts to modify it (Jehng, Johnson, & Anderson, 1993), as well as to provide alternative instruments (Buehl, Alexander, & Murphy, 2002; Hofer, 2000; Schraw et al., 2002), and there have been problems in replicating the factor structure (Clarebout, Elen, Luyten, & Bamps, 2001; Hofer, 2000; Qian & Alvermann, 1995). Thus far, survey instruments appear to capture adequately the two dimensions related to the nature of knowledge—certainty of knowledge and simplicity of knowledge—although these are not always two separate factors (Hofer, 2000; Qian & Alvermann). However, these instruments are less useful in capturing the dimensions related to the nature of knowing—specifically, source of knowledge and justification for knowing, both of which are more evident in the results of interview studies. One possibility is that these latter two dimensions are too complex and multifaceted to yield to simple measurement on a Likert scale. Source of knowledge, for example, appears to take different forms during the developmental progression, moving through phases of subjectivity and objectivity, toward a reconciliation between the two (Belenky et al., 1986; Kuhn & Weinstock, 2002). Given the complexity of this trajectory, it is difficult to ascertain what the midpoint on a Likert scale would actually signify. Similar difficulties exist in the measurement of justification. What seems to be implicit in the epistemological or epistemic beliefs paradigm is the notion that these beliefs can be accessed, known, and recognized by the individual. Those working with a scheme of domain-general beliefs, in particular, seem to presume that these are tacitly held assumptions that can be tapped in a decontextualized manner. Given the absence of success in assessing two of the dimensions in this manner, other approaches are needed.

Methodological Implications of Epistemic Metacognition

Those who have previously identified epistemological thinking at the metacognitive level have posited that it is elicited in ill-structured problem solving, as noted, and thus the means of assessment is to provide such prompts (King & Kitchener, 1994; Kuhn, 1991). In suggesting that epistemological assumptions are metacognitively processed in everyday learning, however, I believe that we can look to a broader body of research on metacognition for approaches to our investigation of this construct. In a review of the methods for assessing metacognition and self-regulation, Pintrich et al. (2000) described a variety of approaches that includes strategy questionnaires, multiple-choice inventories, error-detection studies, interviews, various self-report measures, and think-aloud methodologies.

Each of these approaches could conceivably be utilized in devising measurements to assess epistemic metacognition, and some aspects of existing instruments may also serve in this regard, although they have not been designed as such. For example, the Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1993) includes such items as “When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.” Currently, we are pilot-testing similar items to explore this type of measurement further. However, the methodological approach that has shown promise for exploring the metacognitive nature of epistemic assumptions and beliefs has been the think-aloud protocol, used, for example, in the investigation of epistemological thinking about history (Wineburg, 1991, 1998). Coupled with retrospective interviews (Wineburg, 1998), this technique has considerable power.

Schraw (2000) raised concerns about each of the methods employed by metacognitive researchers, particularly in regard to whether the measures alter the construct. Self-report measures, for example, may lead respondents to produce socially desirable responses, and interviews may prompt information not likely to be considered otherwise. (For example, asking students how they utilized evidence in resolving conflicting positions on a social problem, as is common in some studies, may cause them to consider evidence as a factor when they might not have otherwise.) Think-aloud method-
EPISTEMIC METACOGNITION DURING ONLINE SEARCHING

To explore the metacognitive nature of epistemological understanding, I conducted a set of studies using think-aloud protocols and retrospective interviewing to examine how students engage in epistemic metacognitive processes during online searching for simulated class assignments. This research was guided by three intertwining concerns: (a) that epistemic theories need to be investigated not only through questionnaires and interviews, but also in context; (b) that epistemological aspects of knowledge building as it occurs in everyday learning have often been overlooked; and (c) that student use of the Internet as a medium for learning involves a host of epistemological judgments that deserve more attention. As the way in which students access information and approach learning has shifted to computer-based searching, changing the nature of the task and the information available, we need to know more about the epistemic processes involved as students conduct their searches and construct individual understanding from an array of information.

Online Searching: Personal Epistemology in Practice

Computer searching, whether of library journals or online articles, or on the World Wide Web, has become the routine entry point for identifying and accessing information needed to build knowledge in order to learn about anything new or to expand or challenge ideas about what we believe we already know. The rise of the Internet and the demise of a card catalog physically accessed in library file drawers have permanently altered the process by which students conduct research for class assignments, as well as the process by which nearly any individual seeks information about topics of personal or professional interest. The world that we and our students inhabit is one in which the computer is most often the starting point for a search for information, commonly marked by entering a world of unfiltered information offered by individuals with a range of motives well beyond facilitating learning. The ease of access to online resources has also made physical presence in the library less necessary and the tangible connection to print materials less common. Yet such physical access to published work once made some distinctions clearer to students. For example, even the rudimentary distinction that undergraduates may have been taught to make between “magazines” and “professional journals” is not quite so easily established without the evidence in hand, and newer users may not even have this visual analog in mind.

The rise of the Internet and the increase in student citations of Web sites and use of online journals (and the concomitant decline in the use of either books or bound journal articles) has lead to an outcry among academics, notably in a long line of articles in the Chronicle of Higher Education, including an often cited piece, “How the Web Destroys the Quality of Students’ Research Papers” (Rothenberg, 1997). Of considerable concern are a perceived lack of knowledge on the part of students about differences in types of information and an absence of rigor in evaluating the credibility and veracity of information. Instructors, librarians, and textbook authors have struggled to address these growing concerns, issuing guidelines as part of course syllabi, library Web sites, and textbook supplements; general guidebooks also exist to address these issues (Alexander & Tate, 1999). Among professionals in information science, this has also been a growing topic of research (Kim & Allen, 2002; Spink, 2002), but there has been little assistance from cognitive or educational psychology to guide any in-depth understanding of students’ evaluations and interpretations. Librarians have recently issued their own “white paper” on the topic of Web-based information habits of college students; nearly two thirds of students surveyed felt strongly that they know best what Web-based information they can accept (Online Computer Library Center, 2002).

What is important here, and what needs to claim the attention of educational psychologists, is that many of the concerns that have been raised are not issues of technology but issues of personal epistemology. Fundamentally, as the way in which students access information has changed, we need to be aware of how individuals evaluate sources of knowledge, coordinate theory and evidence, and justify their knowledge assumptions, all aspects of epistemological thinking. This form of learning online through Web searches also presents opportunities for accessing epistemological thinking in new ways. We can begin to look more microgenetically at the dimensions of epistemology, examining, for example, the criteria by which individuals evaluate not only authorities but also the evidence these authorities select to support their particular claims. Utilizing the framework of epistemic metacognition permits us to investigate individuals’ epistemic theories in action. Furthermore, this issue is illustrative of the relevance and critical importance of such investigations for the educational community.

Overview of the Studies

Using think-aloud protocols to access student thinking, my research team investigated a broad series of questions about epistemic metacognition as activated in online searching. Initially, we wanted to explore whether we could tap epistemic metacognition in this manner and whether we could gain ac-
cess to such thinking during online searching. Secondly, we wanted to seek evidence for the dimensions of epistemology in situ, as opposed to the decontextualized manner in which we had captured them through questionnaires. Thirdly, as our model of epistemetic metacognition developed, we wanted to focus on the dimensions of epistemic theories, especially on source of knowledge and justification for knowing, the two dimensions that appear to be part of metacognitive judgments and monitoring (see Table 1), and which have been more difficult to tap through survey methodology. Along these lines, we wanted to know what criteria students used in making their judgments, and, given the large array of information available, how they choose what to read and what to believe and how they strategically approach this process.

We were also interested in how the more tacit assumptions about knowledge, represented in the dimensions of certainty of knowledge and simplicity of knowledge, might be revealed metacognitively and how the four dimensions interacted. In later iterations of the study, we moved on to additional questions. We were interested in learning whether we could track the development of expertise in epistemological awareness through cross-sectional sampling. Finally, in light of concerns about domain specificity or generality of personal epistemology (Buehl et al., 2002; Hofer, 2000; Schommer & Walker, 1995) we wondered whether students were likely to transfer their epistemological sophistication in disciplines where they were developing expertise to those areas where they were likely to be novices. Detailed description of the study and full results will not be provided here, but illustrative responses are offered as representative of this paradigmatic approach.

**Design of the studies.** In each of the three studies conducted thus far, high school and college students were brought into the lab individually, given a simulated assignment for a science course, and asked to conduct a search while thinking aloud. More specifically, in each of the studies students were asked to imagine that they were taking an Introductory Biology course and were assigned to write a paper on the topic of “bees and their communication behavior.” We chose this task because in pilot testing it appeared to engage student interest, yet students generally knew little about it, and because this is a topic that has also engaged scientific researchers throughout the last century. In order to tap the cognitive processes and gain access to individuals’ epistemological thinking during their computer searches, we asked individuals to think aloud (Ericsson & Simon, 1993) during the search, and we videotaped this process.

At the end of timed 20-minute searches, students were asked to choose their three best sources and explain their selection. We also conducted retrospective interviews about their thinking during this process and collected demographic information about computer use, along with science interest and course-taking history. After a review of the first wave of data collection, we altered the task to focus more deliberately on the knowledge-construction aspect, telling students that at the end of the search they would be asked to explain what they knew about the topic, as well as to support their choices of material for their paper. Our goal was to replicate as closely as possible a typical search process in which students are actively learning about a relatively novel topic for a class assignment.

**Brief Summary of Findings**

In this set of studies, as noted, we were interested in learning about the existence of epistemic metacognition during online searching, whether there is evidence of the four dimensions of epistemic theories, and if there is interaction among them. We also looked at the development of expertise and transferability across domains. Guided by methodology for analyzing verbal data (Chi, 1997) and think-aloud protocols (Ericsson & Simon, 1993), we coded along multiple lines. Several main findings show us that this type of investigation is promising:

1. Students can and do make epistemic judgments, metacognitively monitoring the epistemological nature of their learning. The most basic finding is that epistemic metacognition takes place during online learning and can be tapped through think-aloud protocols and further investigated with retrospective interviewing. Throughout their search processes, as we observed and listened, students made comments that indicate epistemic monitoring and judgment—although this does not mean that they necessarily have a high degree of awareness about an explicit epistemology. As we know from studies of reading processes, think-aloud protocols can offer useful access to student thinking that might be less available when queried directly, and applying this methodology to online searching has been productive.

2. There is evidence for each of the four dimensions of epistemic theories as aspects of this process. Based on our theoretical model, we had assumed that certainty and simplicity of knowledge (beliefs about knowledge) would be tacitly held beliefs and perhaps less overtly expressed, and that source of knowledge and justification for knowing (as beliefs about knowing) would be more easily revealed in the process of coming to know. We found evidence for all four and compelling indications that this is a fruitful means for investigating the previously more elusive two, although evidence for the process of justification is much easier to identify than is evidence for what has been intended in the literature by “source of knowledge,” which appears to require greater inference.

3. These beliefs operate interactively, as expected, providing further evidence for the integrated, theory-like nature of the construct, and appear to function in relation to motivation. For example, one student reported that a 1908 book on bees would be adequate for learning about the topic, because
“in biology when they know it, it’s not likely to change,” and said that it was unlikely we had learned much about how bees communicate since then. This indicates a view of both the certainty and simplicity of knowledge; furthermore, such epistemological perspectives appear to have consequences for both seeking information and learning from it. Examination of how students with beliefs such as this pursued the searching task show that the process is brief and perfunctory; if knowledge is finite, why pursue additional sources, or care about more recent information? Nor did such students find it necessary to deliberate about the nature of authority or expertise, demonstrating the integrated nature of such dimensions. Epistemic theories have motivational implications; if knowledge is simple, there is little need to seek further evidence or to integrate information from multiple sources.

4. Individual expertise appears to develop as disciplinary training is advanced and appears more related to course-taking than to age or year in school. For example, by contrast to the student described in the previous example, other students, those with the most expertise in science, were more likely to actively seek recent sources, comment on the changing nature of the knowledge base (“I see that there are two journal articles, one from 1991 and one from 1997, and I would want to read them both and see what the latest one says”), and pursue informed strategies for searching. They were also most likely to make comments such as “I trust this source because it’s from a peer-reviewed journal.” However, when such statements were probed in retrospective interviewing, few seemed to know what “peer-review” actually means or how to independently determine such criteria. Improvement in epistemic monitoring and judgment does develop with training, but at these early phases of induction into a discipline as college undergraduates, it often seems rote. Students appear to have very limited understanding of how knowledge in a field evolves, what counts as authoritative, and why. These are issues that need considered attention from educators.

5. Students were less likely to transfer their discipline-specific expertise in epistemic assessments than we expected. For example, in the wave that included a sample of science majors and nonscience majors, typically only those with the most course training in science were likely to utilize biology databases and seek peer-reviewed scientific journal articles. Even those who were well trained in their own disciplines—for example, upper level psychology majors who knowledgeable discussed PsychInfo as a search mechanism for psychology—were unlikely to transfer that understanding to pursuit of new information in the natural sciences, and instead used general search engines and relied on Web sites rather than journal articles, and made less sophisticated epistemological judgments throughout the search. We hope this study will provide more information about teaching for transfer as we teach information literacy, so that students are less likely to have encapsulated understanding. We also need more research that will pursue the relation between generalized epistemological understanding and discipline-specific beliefs.

As we start a fourth round of data collection, bootstrapping our investigations in this ongoing series of studies, we find we have also learned about other aspects of this process that may be of broader interest. First, students have seldom had any training at all in an educational task they conduct with great frequency, and they have developed highly idiosyncratic heuristics for searching, based on trial-and-error methods. Students commented that they had seldom thought deliberately about how they searched and why they followed the strategies they did. Second, epistemic knowledge is activated at multiple points in online searching, and each of these merits attention by educators. Not only do students make choices among books, journals, magazines, and Web sites, and then again within those categories, but their initial step in computer searching also prescribes what sources will be available to them. In this study, college students far more often than not chose general search engines rather than the college library’s electronic catalog, a portal that has been explicitly narrowed for scholarly work, but one that is also unavailable to most adult learners. Third, as students access information, they then evaluate whether it is useful for their purposes, a mental screening that includes more than a review of the credibility and validity of the source of information. Students appear to ask: How long is it? How specific to my purposes? Is it accessible online or will I have to go to the library to get it? (“Hmmm … They don’t have full text for the American Scientist article, just the abstract, so that can’t work for me at all.”) They also appear to be evaluating the level and intelligibility of the writing, vocalizing comments that indicate they want the appearance of profundity coupled with accessibility. Furthermore, the search process itself is sometimes so onerous that students are happy just to get a match between their search term and any material at all, and seem to spend less time evaluating the material itself than educators might wish. Fourth, we learned how quickly individuals make judgments that occur in the process of seeking and evaluating information. For most of them, this is not a particularly deliberate and thoughtful process, and the rapidity with which students viewed information and discarded it was startling. The influence of domain expertise on deliberation time and evaluation criteria could be a productive avenue of inquiry.

CONCLUSIONS

As we continue to explore the metacognitive aspects of epistemic understanding, we need to consider further the contexts in which these processes are prompted and to expand our investigations of this construct. Using think-aloud protocols and other methodology appropriate to the study of metacognition, we can begin to learn more about how stu-
tudents’ conceptions of knowledge and knowing influence their learning. The findings of this particular study could be the basis for integrating epistemological awareness as a component of computer information literacy in developmentally appropriate ways and, accordingly, could be used to enhance students’ ability to think critically about seeking and evaluating information.

Furthermore, such research could be useful in both developing domain-specific interventions as well as more general interventions that could be designed with the goal of transfer of understanding. Researchers in this area have been persuasive in arguing that epistemological thinking matters (Kuhn & Weinstock, 2002), but training students to be more metacognitively aware in an epistemological sense may be more important than ever, with the rise and ease of computer access to information and educational goals of information literacy. We need to expand our understanding of these processes and design interventions that can be addressed by educators at all levels, truly preparing individuals for lifelong learning.

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