Book Chapters

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Epistemic Cognition and Motivation

Jason A. Chen
College of William & Mary, jachen@email.wm.edu

Michael M. Barger
Duke University

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Jason A. Chen
The College of William & Mary

Michael M. Barger
Duke University

Correspondence:
Jason A. Chen
College of William & Mary
School of Education
PO Box 8795
Williamsburg, VA 23187-8795

Phone: (757) 221-6201
Fax: (757) 221-2988
jachen@email.wm.edu

Why do you want to teach? What are the reasons you decided to major in philosophy in college? Why did you consult three different physicians *and* comb through hundreds of medical journals just to find out whether you should have your daughter vaccinated—isn't asking your own doctor sufficient? Motivation is at the root of all of these types of questions. Motivation researchers are primarily concerned with the cognitive processes by which people initiate and sustain behaviors. For example, if a group of teachers indicate they decided to teach because they believe ensuring the next generation of young people enters their adult lives prepared to face the challenges of the 21st century, then these teachers are likely describing a belief in the *utility* of what they do. On the other hand, if a student said she decided to major in philosophy because she took introductory courses in logic and in ethics and earned superior marks in these classes, then her *competence beliefs* are likely the most salient aspect of her motivation.

Although motivation historically has been presented in many different ways (e.g., need satisfaction, innate drives), in this chapter we frame the most commonly studied constructs of motivation as important cognitive structures and processes that guide our behaviors. We conceive of behaviors in a broad sense of the word to also include cognitive behaviors such as asking oneself whether a certain strategy is the best approach to solve a problem. This focus is in line with the purpose of this chapter and handbook—to focus on cognitive structures and processes that guide behaviors related specifically to building and evaluating knowledge. Given this focus on the cognitive basis of motivation, we then explore how motivational aspects of cognition relate to aspects of cognition that concern the nature of knowledge and knowing. Although the literature about the intersection of motivation and epistemic cognition is relatively small, scholars are becoming increasingly interested in questions such as, "why might some students refer to a politician about whether vaccines are effective and safe rather than refer to

their family doctor?" At the heart of these types of questions is the assumption that cognitive behavior (including epistemic cognition) is motivated. That is, might some students refer to their teachers as the definitive source for an answer because they believe that it is not worth the time and effort to find more nuanced answers from multiple sources of information? Or might other students seek out alternative answers that are different from their textbook because they want to show off to their peers and teachers about how smart they are?

To understand the linkages between motivation and epistemic cognition, however, we must first understand the theoretical frameworks that guide research in motivation as well as the empirical findings that have supported them. Motivation is a very broad construct that can include competence beliefs (i.e., "Am I able to do this task?"), value beliefs (i.e., "Do I find this task compelling?"), and goal orientations (i.e., "What is the reason I am engaging in this task?"). Given the large number of constructs included under the umbrella term of motivation, clarification is necessary regarding which constructs are typically included when researchers describe motivation. From there, we explore the studies that have examined the links between epistemic cognition and motivation, we consider ways that theory on epistemic cognition has implicitly enveloped motivational constructs, and we delineate how clear motivational constructs might inform such research. We conclude by exploring areas where future research is needed, and offer comments about the types of studies that may be productive for the field.

<p style="text-align:center">Frameworks for Understanding Motivation</p>

Understanding What People Value

One family of constructs that has received a considerable amount of attention in the motivation literature is individuals' *beliefs about the value* of a task or subject area. People's motivation to do any task is tied to the value they see in doing it. Eccles and Wigfield (2002)

suggest there are four major components to this value component: *attainment value*, which is the importance of doing well on a given task; *intrinsic value*, which is the enjoyment one gains doing a task; *utility value*, which is defined as how a task fits into an individual's future plans or personal agenda; and *cost,* which refers to what the individual has to give up in order to do a task and how much effort must be exerted. Research has shown that students' task values predict whether or not they actually pursue a task (Battle & Wigfield, 2003; Durik, Vida, & Eccles, 2006; Simpkins, Davis-Kean, & Eccles, 2006). This is especially true regarding career choices (Brophy, 2009). Research has shown that when students perceive a task to be useful for their future endeavors, they are more likely to initiate an activity and remain engaged in it (Greene, Miller, Crowson, Duke, & Akey, 2004; Johnson & Sinatra, 2013; Miller & DeBacker, 1999), and do better on measures of achievement (Cole, Bergin, & Whittaker, 2008; Greene et al., 2004).

A closely related way to examine whether students find a task compelling is research on *interest*, the positive cognitive and emotional reaction a person has to a specific object (Hidi & Renninger, 2006; Schiefele, 1991). The object in an academic setting might be a particular task, topic, or subject area. Researchers further divide interest into individual interest, which a student holds toward the object in general, and situational interest, which is brought about by a particular context (Mitchell, 1993; Schiefele, 2009). As an example, a student might not be very interested in science, but could become highly engaged in an experiment that involves colorful chemical reactions or appreciate science when a particular teacher describes how science makes the world a better place. Situational interest can develop into individual interest under the right circumstances (Hidi & Renninger, 2006).

Understanding People's Competence Beliefs

Researchers concerned with people's competence beliefs often focus on two constructs that have received the lion's share of research in motivation. The first construct is self-efficacy, which Bandura (1997) defined as individuals' beliefs about their own capabilities to learn or perform tasks at designated levels. A wealth of research has shown that students' self-efficacy plays an important role in their academic success and in the academic choices they make (Schunk & Pajares, 2005). Students' academic self-efficacy has been shown to relate to (a) their performance in many different academic subjects, (b) their level of interest in those subjects, (c) the amount of effort they put forth in accomplishing those academic tasks, and (d) their subsequent career choices (see Pajares & Urdan, 2006).

A second major construct discussed in reference to students' competence beliefs is their *implicit theories of ability*, which (Dweck & Leggett, 1988) described as the view that individuals hold of their ability as either a fixed entity or as a quality that can change with effort and appropriate strategies. Those who adopt a fixed theory of ability tend to view their ability as a relatively static trait that cannot be changed, whereas those who adopt an incremental theory of ability are more likely to believe their ability can change. Decades of research have shown that implicit theories of ability predict academic achievement (Aronson, Fried, & Good, 2002; Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2007; Hong, Chiu, Dweck, Lin, & Wan, 1999; Robins & Pals, 2002; Stipek & Gralinski, 1996). The literature in this field has shown that implicit theories do not influence achievement directly, however. Their influence is mediated by students' goal orientations.

Understanding the Orientation of People's Goals

Goal orientations have had an extensive history in the motivation literature (see Maehr & Zusho, 2009). They deal with individuals' *reasons* for initiating a task and continuing to engage

in it. In the academic domain, there are two broad orientations from which students might approach a task (Ames & Archer, 1988; Elliott & Dweck, 1988; Nicholls, 1984). They could adopt a performance goal, seeking to demonstrate competence to others. Alternatively, they could endorse a mastery or learning goal, pursuing a task for the sake of improving skills and understanding. Goals might also be divided further by whether students are approaching or avoiding the possible outcome (Elliot & Church, 1997; Elliot & McGregor, 2001). For instance, students might have a performance approach goal, in which they want to demonstrate how smart they are, or a performance avoidance goal, in which their main objective is not to appear incompetent at the task.

Scholars have noted that individuals often orient themselves toward different personal goal orientations because of the "messages in the learning environment (e.g., the classroom or school) that make certain goals salient" (Urdan & Schoenfelder, 2006, p. 334). In classrooms that emphasize social comparison, the goal structures could be described as performance oriented, whereas in classrooms in which deep learning and understanding are valued rather than surface-level memorization the goal structures could be considered mastery-oriented. Decades of research have demonstrated that mastery goal structures are associated with adaptive learning patterns (for a review see Meece, Anderman, & Anderman, 2006), suggesting that environmental factors created within classrooms could be contributing to the ways in which students orient themselves to academic tasks.

In sum, motivation is a broad field composed of many different constructs and theoretical frameworks. It is a field of study concerned with addressing the question, "why do people behave the way they do?" Answers could pertain to, among others, beliefs about competence, beliefs about the value that people place on a task, or the goals to which people orient

themselves. Traditionally, these beliefs have been studied in relation to observable behaviors such as solving mathematics problems or pursuing careers in various fields. Yet, how might motivation play out in the context of epistemic cognition in which the behaviors might be more invisible?

How Scholars in Epistemic Cognition Have Approached Motivation

If students believe, for example, that one historian's account of how World War II began is indisputably true, might there be motivational consequences to this belief? Would the motivational consequences for these students be different from their peers who believe that the "true" cause of WWII can never be fully known, and that this historian's account is merely one point of view about an event? Scholars who have explored these types of questions are concerned with the relationships between students' epistemic cognition regarding a field of study and their motivation to engage in that field of study. We examine this line of inquiry next.

Epistemic Cognition and Relations to Motivation

Drawing from research in mathematics education (Schoenfeld, 1983, 1989), Schommer (1990) set out to investigate what she called epistemological beliefs and their relationship to learning. Here we will use the more common "epistemic" belief. Her underlying assumption was that epistemic beliefs influenced how students learned academic material, which was in line with Schoenfeld's assumptions regarding mathematics learning. Schommer posited that epistemic beliefs included beliefs about the *structure* of, *certainty* of, and *source* of knowledge, as well as the *speed* and the *control* of knowledge acquisition. The construction of the latter two dimensions was influenced by Schoenfeld's findings regarding students' beliefs about mathematical knowledge being ascertained very quickly (speed of knowledge acquisition), and

by Dweck and Leggett's (1988) work regarding people's beliefs about the malleability of their intelligence.

The empirical literature supporting Schommer's (1990) framework of epistemic beliefs has shown that beliefs about knowledge and knowing have important relationships to motivation. Early scholarship suggested that epistemic beliefs give rise to students' motivation. This likely emanated from Hofer and Pintrich's (1997, 2002) hypothesis that epistemic beliefs might function as a type of implicit theory that gives rise to students' motivational orientations. The studies that follow point to this possibility, in which epistemic beliefs orient students toward certain types of goals, which then have implications for the ways in which students regulate their motivation.

In one example, Bråten and Strømsø (2004) revealed one aspect of how epistemic beliefs function like a type of implicit theory by showing that students who believed in stable and unchanging knowledge (considered less constructivist) were less likely than their peers with more constructivist orientations to adopt mastery goal orientations. Similarly, Chen and Pajares (2010) showed through a path analysis that an incremental view of ability in science was directly related to students' beliefs that scientific knowledge is dynamic and evolving, and that experimental results are a good way to generate new questions about science (rather than serve as simple demonstrations about things we already know to be true). They also found that fixed views of ability in science were directly related to students' beliefs that scientific knowledge is best described as coming from an external authority rather than from one's own personal reasoning and thoughts, and that scientific knowledge consists mostly of truths that are knowable with certainty. These findings suggested that views about malleable intellectual capacity were related to views about a dynamic nature of knowledge, which were in turn related to higher end-

of-year grades. On the other hand, those who viewed attributes such as intelligence or scientific knowledge as static were more likely to characterize those attributes as simplistic, all-or-nothing, entities. Similar to Bråten and Strømsø's (2004) work, Chen and Pajares's study suggested these beliefs about the dynamic nature of ability and knowledge were indirectly related to self-efficacy, self-regulatory beliefs, and ultimately students' grades through their effects on goal orientations.

A similar study by Mason, Boscolo, Tornatora, and Ronconi (2012) showed through a path analysis that, for students in Grades, 5, 8, and 11, the more students believed in scientific experimentation as a tool used to provide evidence for questions and to generate new questions to ask, the more likely these students were to pursue learning activities to understand the material. They also found, although students' belief in an uncertain and constantly evolving scientific knowledge base was not significantly related to goal orientations, this belief was directly related to science knowledge. These findings extend those from Chen and Pajares (2010).

Beghetto and Baxter (2012) used structural equation models to explore the relationships between self-efficacy, epistemic beliefs, intellectual risk-taking (the willingness to share tentative ideas, ask questions, and try new tasks), and teachers' rating of students' understanding of science or mathematics. Although their findings in science mirrored the findings of the aforementioned studies, Beghetto and Baxter found that students who held their own *mathematics* competence in high regard were more likely to believe that mathematical knowledge was external to them. This may reflect a belief that mathematical competence has to do with understanding knowledge from competent experts, and less to do with developing the conceptual understanding to solve problems creatively in a variety of ways.

Finally, although the vast majority of studies concerning the relationships between epistemic cognition and motivation are cross-sectional, we point to one experimental study that specifically isolated epistemic cognition and explored the effects of such a manipulation on outcomes that included motivation. In a quasi-experimental study, Muis and Duffy (2012) manipulated the epistemic climate of classrooms such that students in the intervention condition experienced a classroom environment that demonstrated statistics knowledge as contestable and constantly evolving. Students in the control condition experienced statistics instruction in a traditional format that did not challenge the epistemic climate. They found that students in the intervention classroom evinced changes toward more constructivist stances, which coincided with increased statistics self-efficacy. The authors posited that, because of the intervention, students changed the ways in which they thought about statistics knowledge, and in turn, used different strategies to understand the material, which forced students to more deeply process the material. Ultimately, this resulted in greater self-efficacy for mastering the content. Students' self-reported epistemic beliefs and motivation in the control condition, however, remained constant.

Taken together, the aforementioned studies suggest that, when a field of study (e.g., science or statistics) is presented as a dynamic body of knowledge that requires individuals to inquire deeply to understand the subject, then students are more likely to orient their goals toward understanding the subject rather than demonstrate their competence to others or avoid appearing incompetent. In turn, when classroom structures encourage mastery goals people are more likely to embark on a trajectory that involves expending additional effort to self-regulate their learning and develop strategies to better understand the material.

The Motivation Behind Epistemic Cognition

The line of inquiry we just outlined explores relationships between the different dimensions of epistemic cognition on the one hand and motivation toward a particular academic subject on the other hand. Another way in which scholars in epistemic cognition have studied issues related to motivation is by exploring the reasons why individuals would *want to* engage in thinking about knowledge and knowing in the first place. Chinn and colleagues (Chinn, Buckland, & Samarapungavan, 2011; Chinn, Rinehart, & Buckland, 2014) have pioneered this line of inquiry under what is often referred to as epistemic cognition (Greene, Azevedo, & Torney-Purta, 2008), which is a far more expansive construct than the epistemological beliefs mentioned earlier. This expanded perspective seems to fold motivation constructs into epistemic cognition. That is, it acknowledges that thinking about knowledge is not merely a "cold" cognitive process (Pintrich, Marx, & Boyle, 1993), but a "hot" process that involves affective and motivational components.

This expansion of epistemic cognition includes the traditional epistemic beliefs, but also includes components such as epistemic aims, epistemic values, and the reliability of processes used to obtain knowledge (Chinn et al., 2011). Epistemic aims are the goals that people adopt toward knowledge. Epistemic aims are directed toward end-states of knowledge pursuit, called epistemic achievements, which might vary from obtaining true facts or understanding the relations between these facts. In differentiating epistemic aims from non-epistemic aims, Chinn, Rinehart, and Buckland (2014) argued that the latter are aims that are not specifically directed toward knowledge. For example, the epistemic aim of understanding differs from the non-epistemic aims of experiencing pleasure or maintaining self-image, even though such aims might interact.

There are similarities in Chinn and colleagues' framework to work done by scholars studying goal orientations. For example, a mastery goal orientation involves a primary focus on the actual act of learning and understanding *for learning's sake*. Two common mastery goal measures (Achievement Goal Questionnaire, Elliot & McGregor, 2001; Patterns of Adaptive Learning Survey, Midgley et al., 2000) include items that get at the act of seeking to understand: "One of my goals in my classes is to learn as much as I can," and "It is important to me to understand the content of this course as thoroughly as possible." Performance goal orientations, on the other hand, particularly those with a normative standard (Elliot, Murayama, & Pekrun, 2011), involve a primary focus on demonstrating competence to others. Although students can certainly demonstrate competence to others while also trying to understand something deeply, the emphasis is on which goal is the primary focus. However, in the case of a multiple goal pursuit (e.g., Barron & Harackiewicz, 2000; Daniels et al., 2008; Pintrich, 2000) students might be oriented toward juggling both types of goals. This issue of a multiple goal pursuit could inform scholarship on epistemic and non-epistemic aims (Chinn et al., 2014). For example, just as it is quite reasonable to read a book both for the sake of learning about the history behind modern models of the atom, as well as to read the book to ace a test (i.e., orientation toward both a mastery and a performance goal), the same is true for epistemic cognition. That is, students could be oriented toward understanding the biases behind a particular author's version of history so as to understand the complexity of the issue (an epistemic aim). However, these same students could also be oriented toward understanding the authors' biases in order to be esteemed by their peers for finding an interesting insight (a non-epistemic aim).

Whereas the discussion about epistemic aims reveals similarities to goal orientations, Chinn, Buckland, and Samarapungavan (2011) also included features in their model that relate to

issues of understanding what people value. For example, Chinn et al. noted that epistemic aims can be informed by what they call epistemic values—epistemic achievements that individuals find interesting, useful, or otherwise compelling. If an individual sees, for example, video footage of archaeologists discovering the remains of a human skeleton in the early Jamestown settlement that suggested cannibalism during the "starving time" of 1609 to 1610, this startling discovery might trigger excitement and interest in understanding the circumstances surrounding the situation. This interest trigger might then recruit a series of behaviors directed toward whichever goal or combination of goals this student is oriented toward.

To play out the complex interactions between epistemic aims, epistemic values, and motivation, we present two hypothetical scenarios. First, going to the earlier example of Jamestown, if classroom conditions are such that students have to sift through evidence from primary sources and forensics results to seek a better understanding of what life was like in the "starving time," students' motivation could certainly be recruited toward treating knowledge in history as tentative (i.e., we do not know for sure what life was like in Jamestown to have led to cannibalism) and highly complex (i.e., understanding the situation requires historians, archaeologists, and scientists). On the other hand, if classroom conditions are such that students are presented with a news story about how forensic scientists discovered that a person was cannibalized during the "starving time," and that the colonists were incompetent farmers and so could not produce enough food for themselves, motivation could certainly be recruited toward treating historical knowledge as certain (i.e., we know for certain that the colonists were inept and therefore could not produce enough food, which led to cannibalism) and somewhat simple (i.e., finding the answer to the question was a forensic science issue that does not require historical knowledge to figure out). Notice that in both scenarios if the classroom centered on a

highly engaging activity in which students worked collaboratively about a real-life problem that actual professionals deal with, students could see the value of wrestling with issues related to knowledge and knowing, and they could develop the competence beliefs to do so. Researchers and practitioners could consider these activities to be quite motivationally sound. However, in the first case, presenting a more comprehensive case of the types of inquiry happening in Jamestown recruits students' cognitive resources (both epistemic and motivational) toward a more nuanced and adequate picture of knowledge and knowing. Whereas in the second case, although a compelling and interesting presentation of the material could be motivating, that motivation may be directed toward a more simplistic view of knowledge and knowing. We bring this up because in scholarship that explores the relationship between epistemic beliefs and motivation, such as in Chen and Pajares's (2010) or Bråten and Strømsø's (2004) work, their results suggest that more nuanced and complex views of knowledge and knowing are related to more adaptive forms of motivation. However, in the epistemic cognition framework outlined by Chinn, Buckland, and Samarapungavan (2011) beliefs about value, competence, and goal orientations can be directed toward any variety of outcomes that can vary widely in how nuanced they are, which can be epistemic or not. Such a line of inquiry requires a conception of and measures of motivation and epistemic cognition that are highly specific, both to the domain and likely even to the task in which students are engaged.

　　As the field has expanded from conceptualizing a set of personally held beliefs about knowledge to a broad spectrum of cognitive processes related to knowledge seeking, motivation has implicitly been folded into the framework of epistemic cognition. Researchers in both fields have begun to bridge the gap between these two critical components of learners' thinking and behavior. This expanded conceptualization of epistemic cognition has generated an exciting

array of questions and lines of inquiry that researchers can pursue. In the final section of this chapter, we pose some of these lines of inquiry, with a specific focus on the intersection of epistemic cognition and motivation.

<div align="center">**Future Directions for Research**</div>

Epistemic achievements are a worthy educational outcome in their own right. However, schooling has long been considered a means to an end. For example, students are told to get good grades and do well on tests so that they can get into a good college and/or get a good job (Kuhn, 2003). Over a decade ago, Kuhn (2003) argued that, "once an activity becomes identified as merely a means to an end, it becomes easy to devalue it as without significance in its own right. One undertakes it because it produces some totally different dividend that is valued" (p. 18). Later, she argued that intellectual pursuits should be valued because the activities that produce intellectual achievements are valuable in and of themselves, and that students can and do experience these activities and achievements as enjoyable in their own right. The question Kuhn posed was, "what makes it happen?" What allows for students to derive intrinsic enjoyment and value in engaging in intellectual pursuits? One answer that she posed was that, "students' developing understanding of what it means to learn and to know is a key component of the process. … Their school experiences are for most students the primary basis for the understandings they construct of what it means to learn and know and, not incidentally, whether investing one's time and effort in such pursuits is worthwhile" (p. 18). At the heart of this issue is finding ways for students' motivation toward wrestling with knowledge and knowing in progressively more adequate ways to flourish. Current classroom and school conditions, for the most part, make it difficult to see the value of engaging in activities that do this. However, we believe that research at the intersection of epistemic cognition and motivation can draw on these

two frameworks to investigate the ways in which educators, policy makers, and instructional designers can create environments and activities that make engaging in intellectual activities that focus on forming progressively more adequate ways of dealing with knowledge and knowing an integral and valued part of students' experiences in a large variety of fields.

Integrating Frameworks for Epistemic Cognition and Motivation

Central to the problem of creating environments in which students find it worthwhile to engage in intellectual pursuits is what motivation researchers would call value beliefs. The vast literature about the development of interest and intrinsic motivation could be of great help to those exploring how students' interests in engaging in activities that lead to progressively more adequate epistemic achievements are triggered in the first place. Furthermore, how are students' interests in these activities not just triggered for a moment, but also *sustained* so that students are likely to re-engage in activities that lead to progressively more adequate epistemic achievements throughout their lifetime unprompted from external requirements? When we say "progressively more adequate epistemic achievements" we are describing movements toward a more comprehensive understanding of issues, knowledge, and/or skills in which students see evidence and rationales for a variety of positions, but ultimately commit to one stance based on reason and evidence.

Of course, all of this cognitive activity directed toward epistemic achievements requires the enlistment of motivation to exert the effort to engage in these types of activities in the first place. Current theories of interest development (see Hidi & Renninger, 2006) may help us in this regard. *Triggered situational interest* refers to a psychological state that results from momentary changes in affect. These triggers are usually externally supported (Hidi & Renninger, 2006).

Future research could investigate the types of activities and cues that trigger an interest specifically to think critically about knowledge and knowing.

In particular, because students are engaging in activities and are consuming and using information in an increasingly mediated world—accessing stories, entertainment, messages, and other information from portable and connected devices—researchers and educators need to understand the variety of conditions that trigger students' interests within these virtual learning environments to think specifically about progressively more adequate conceptions of knowledge and knowing. For example, it is easy to read a news story from one's social media feeds without thinking critically about the adequacy of the claims made in the article. What are some ways in which educators, instructional designers, and researchers can trigger students' interests in enlisting their cognitive resources toward things such as exploring who wrote the news piece and why that matters, or thinking about whether or not the claims are well justified? Some research has shown that interest can be triggered by using novelty (Palmer, 2009), promoting student autonomy (Palmer, 2009; Skinner, Furrer, Marchand, & Kindermann, 2008), using group work (Minnaert, Boekaerts, & Brabander, 2007), and making the utility of an activity salient (Hulleman, Godes, Hendricks, & Harackiewicz, 2010). Yet, we know little about the *specific* activities that trigger students' interests toward reasoning about knowledge and knowing in progressively more adequate ways. For example, Sandoval and Harven (2011) found that autonomy, although an important general principle for promoting motivation in students, was especially beneficial in triggering students' interests in science inquiry when the activities had to do with collecting and analyzing data. However, in order to trigger students' interests in focusing on the epistemic components of data collection and analysis, what specific things do educators and instructional designers need to make salient? In addition, Sandoval and Harven found that

tasks related to investigation, rather than tasks related to argumentation, appeared to have the greatest effect on triggering students' interests because students noted the high value of having evidence to back up one's own ideas.

The intriguing findings from Sandoval and Harven (2011) above lead to another issue. Triggering an interest in thinking about knowledge and knowing is one thing, but sustaining that interest is quite another endeavor. Yet, this is a critical component in developing students' long-term and enduring *individual interests* toward an activity. Sandoval and Harven noted that the key feature that seemed promising in sustaining interest was students' desire to be able to have good evidence to support their ideas. This suggests that making the utility of tasks salient holds promise in sustaining students' interests. However, because students who perceive something to be useful but also do not believe that they can accomplish this valuable task are likely to experience quite negative academic and motivational outcomes (see Bandura, 1997), future research also needs to explore the variety of ways to support both students' beliefs about utility and their beliefs about their own competence.

In addition, research has shown that, whereas the earlier phases of interest development, such as triggering interest, are primarily affective, the later phases of interest development, such as well-developed individual interest, also require that students possess a sufficient stock of knowledge and a well-developed self-efficacy. Future research could investigate the specific types of knowledge that need to be built up so that students' individual interest to engage in activities that lead to progressively more adequate epistemic achievements can develop. For example, what outcomes could be likely if students have a large store of knowledge about the variety of sources from where knowledge can come (i.e., professional mathematician, teachers,

peers, books, and even themselves), but have little knowledge about how to adjudicate among all the sources?

As we mentioned earlier, self-efficacy is a key determinant in students' academic choices, including choices to recruit cognitive resources toward dealing with knowledge and knowing in progressively more adequate ways. Because self-efficacy is so important researchers have begun to investigate what fuels self-efficacy. Bandura (1997) posited that there are four sources of self-efficacy. Students' perceived past successes inform their beliefs about how well they can perform in future endeavors. These *mastery experiences* are thought to be the strongest source of self-efficacy (see Usher & Pajares, 2008). However, in the absence of sufficient mastery experiences, students need to draw from other sources such as *vicarious experiences* (thinking, "if they can do it, then so can I"), *social persuasions* (the spoken and unspoken messages from significant others that inform our self-efficacy), and *affective states* (anxiety, adrenaline rush, moods, and other feelings). Although researchers have explored these broad categories regarding the antecedents of self-efficacy, less well-known are the specifics of these sources. For example, if mastery experiences are the strongest source, then what exactly counts as a mastery experience? Also, if the strength of vicarious experiences and social persuasions depends on how well a student identifies with or trusts the vicarious model or persuader, then what specific things encourage a strong identification or trust? As it relates to thinking about knowledge and knowing, what specific experiences could tell students that they have, for example, successfully adjudicated between several sources of knowledge? What characteristics do students look for when they identify a suitable role model who can show them how to handle knowledge and knowing in progressively more adequate ways?

Overall, the questions and lines of inquiry we have posed regarding the development of interest and self-efficacy require researchers to be able to capture data about the more fine-grained tasks students undertake so that educators and instructional designers can create learning environments that build students' self-efficacy and take full advantage of interest-triggering and interest-sustaining features that can lead to enduring individual interests in thinking about knowledge and knowing in sophisticated ways. In our final section, we discuss issues related to capturing these data.

Issues of Measurement

Research in epistemic cognition has had a long history of measurement issues (see DeBacker, Crowson, Beesley, Thoma, & Hestevold, 2008). One reason for this might be because students' epistemic cognition often operates "under the radar" such that students are unaware of what their epistemic aims are, for example, or what they believe about the certainty of a knowledge claim even if they are prompted to think about them. In addition, students might be able to articulate only a limited set of their cognitions related to knowledge and knowing (i.e., they might articulate their beliefs about the source of knowledge, but not their epistemic values). Furthermore, students' cognitions (both epistemic and motivation) may only crystallize or become activated when presented with a situation in which they have to act, which means that measures need to be quite context and task specific. These cognitions are very likely to vary depending on the situation, such that in one situation students might set an epistemic aim of understanding and learning about a knowledge claim, but 10 seconds later might set a non-epistemic aim of trying to impress their peers. Therefore, we encourage researchers to explore a variety of ways to assess students' epistemic cognition and motivation, especially in ways that allow researchers to tap these cognitions and beliefs *in situ*.

One way to innovate the ways epistemic cognition and motivation are measured is to leverage the capabilities of computers. Researchers are already using computers as assessment tools to assess cognitive activities. For example, the *SAVE Science* project (see Ketelhut, Nelson, Schifter, & Kim, 2013; Nelson, Kim, Foshee, & Slack, 2014) use immersive virtual environments (IVEs) to assess students' scientific inquiry skills. Rather than assessing scientific inquiry by using multiple-choice questions, these virtual assessments allow researchers to collect large amounts of information regarding students' actions in the virtual world. Inferences can be made regarding students' thinking as they reason through complex scientific problems. Other virtual environments such as *Epistemic Games* (http://edgaps.org/gaps/) also seek to create models that assess complex problem solving skills.

In a similar way, researchers can use these types of virtual assessments to infer students' motivation and epistemic cognition. For example, scientific inquiry skills require students to collect data from a variety of sources, use experimental data to make inferences, and use the information to come to some conclusions. These types of inquiry processes tap into issues of epistemic cognition by getting at students' beliefs about a scientific authority or how much they trust visual cues in the IVE versus the experimental results they obtained. When students have to perform an action, these actions are likely goal-directed. It could be quite feasible to assess whether the goals are directed toward knowledge or toward non-epistemic aims. These are only a few examples of the variety of beliefs and cognitions that researchers could gather from using these IVEs.

Although such assessments are not meant to replace traditional assessments such as self-report questionnaires, virtual assessments certainly can provide researchers with more fine-grained, in-the-moment information regarding the goals that students are oriented toward when

pursuing epistemic achievements, the value they see in attaining these epistemic achievements, and students' beliefs about whether they can muster their resources toward successfully reaching these epistemic achievements. In that way, these virtual assessments can offer a more nuanced look into students' motivation and epistemic cognition. However, there are issues of validity and reliability that need to be addressed before researchers can make claims about students' cognitions and beliefs, and their relationships with other outcomes of interest. This is a ripe area of research, and one that will require researchers to find creative yet rigorous ways to evaluate how valid and reliable these dynamic assessments are. We are excited by these possibilities for future research, and encourage scholars to continue using innovative technologies not just as learning and teaching tools, but also as a way to assess students' cognitions.

REFERENCES

Ames, C., & Archer, J. (1988). Achievement goals in the classroom: Students' learning strategies and motivation processes. *Journal of Educational Psychology*, *80*(3), 260–267.

Aronson, J., Fried, C. B., & Good, C. (2002). Reducing the effects of stereotype threat on African American college students by shaping theories of intelligence. *Journal of Experimental Social Psychology*, *38*(2), 113–125. http://doi.org/10.1006/jesp.2001.1491

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Barron, K. E., & Harackiewicz, J. M. (2000). Achievement goals and optimal motivation: A multiple goals approach. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation* (pp. 229–254). San Diego: Academic Press.

Battle, A., & Wigfield, A. (2003). College women's value orientations toward family, career, and graduate school. *Journal of Vocational Behavior*, *62*(1), 56–75. http://doi.org/10.1016/S0001-8791(02)00037-4

Beghetto, R. A., & Baxter, J. A. (2012). Exploring student beliefs and understanding in elementary science and mathematics. *Journal of Research in Science Teaching*, *49*(7), 942–960. http://doi.org/10.1002/tea.21018

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development*, *78*(1), 246–263.

Bråten, I., & Strømsø, H. I. (2004). Epistemological beliefs and implicit theories of intelligence as predictors of achievement goals. *Contemporary Educational Psychology*, *29*(4), 371–388. http://doi.org/10.1016/j.cedpsych.2003.10.001

Brophy, J. (2009). Connecting with the big picture. *Educational Psychologist*, *44*(2), 147–157.

> http://doi.org/10.1080/00461520902832400

Chen, J. A., & Pajares, F. (2010). Implicit theories of ability of Grade 6 science students:

> Relation to epistemological beliefs and academic motivation and achievement in science.

> *Contemporary Educational Psychology*, *35*(1), 75–87.

> http://doi.org/10.1016/j.cedpsych.2009.10.003

Chinn, C. A., Buckland, L. A., & Samarapungavan, A. (2011). Expanding the dimensions of

> epistemic cognition: Arguments from philosophy and psychology. *Educational*

> *Psychologist*, *46*(3), 141–167. http://doi.org/10.1080/00461520.2011.587722

Chinn, C. A., Rinehart, R. W., & Buckland, L. A. (2014). Epistemic cognition and evaluating

> information: Applying the AIR model of epistemic cognition. In D. N. Rapp & J. L. G.

> Braasch (Eds.), *Processing inaccurate information: Theoretical and applied perspectives*

> *from cognitive science and the educational sciences* (pp. 425–453). Cambridge, MA:

> MIT Press.

Cole, J. S., Bergin, D. A., & Whittaker, T. A. (2008). Predicting student achievement for low

> stakes tests with effort and task value. *Contemporary Educational Psychology*, *33*(4),

> 609–624. http://doi.org/10.1016/j.cedpsych.2007.10.002

Daniels, L. M., Haynes, T. L., Stupnisky, R. H., Perry, R. P., Newall, N. E., & Pekrun, R. (2008).

> Individual differences in achievement goals: A longitudinal study of cognitive,

> emotional, and achievement outcomes. *Contemporary Educational Psychology*, *33*(4),

> 584–608. http://doi.org/10.1016/j.cedpsych.2007.08.002

DeBacker, T. K., Crowson, H. M., Beesley, A. D., Thoma, S. J., & Hestevold, N. L. (2008). The challenge of measuring epistemic beliefs: An analysis of three self-report instruments. *The Journal of Experimental Education*, *76*(3), 281–312.

Durik, A. M., Vida, M., & Eccles, J. S. (2006). Task values and ability beliefs as predictors of high school literacy choices: A developmental analysis. *Journal of Educational Psychology*, *98*(2), 382–393. http://doi.org/10.1037/0022-0663.98.2.382

Dweck, C. S. (2007). Is math a gift? Beliefs that put females at risk. In S. J. Ceci & W. M. Williams (Eds.), *Why aren't more women in science: Top researchers debate the evidence* (pp. 47–55). Washington, DC: American Psychological Association.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review*, *95*(2), 256–273. http://doi.org/http://psycnet.apa.org/doi/10.1037/0033-295X.95.2.256

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*(1), 109–132.

Elliot, A. J., & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology*, *72*(1), 218–232. http://doi.org/http://psycnet.apa.org/doi/10.1037/0022-3514.72.1.218

Elliot, A. J., & McGregor, H. A. (2001). A 2x2 achievement goal framework. *Journal of Personality and Social Psychology*, *80*(3), 501–519. http://doi.org/http://psycnet.apa.org/doi/10.1037/0022-3514.80.3.501

Elliot, A. J., Murayama, K., & Pekrun, R. (2011). A 3x2 achievement goal model. *Journal of Educational Psychology*, *103*(3), 632–648. http://doi.org/10.1037/a0023952

Elliott, E. S., & Dweck, C. S. (1988). Goals: An approach to motivation and achievement. *Journal of Personality and Social Psychology*, *54*(1), 5–12. http://doi.org/http://psycnet.apa.org/doi/10.1037/0022-3514.54.1.5

Greene, B. A., Miller, R. B., Crowson, H. M., Duke, B. L., & Akey, K. L. (2004). Predicting high school students' cognitive engagement and achievement: Contributions of classroom perceptions and motivation. *Contemporary Educational Psychology*, *29*(4), 462–482. http://doi.org/10.1016/j.cedpsych.2004.01.006

Greene, J. A., Azevedo, R., & Torney-Purta, J. (2008). Modeling epistemic and ontological cognition: Philosophical perspectives and methodological directions. *Educational Psychologist*, *43*(3), 142–160. http://doi.org/10.1080/00461520802178458

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41*(2), 111–127.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, *67*(1), 88–140. http://doi.org/10.3102/00346543067001088

Hofer, B. K., & Pintrich, P. R. (Eds.). (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahway, NJ: Lawrence Erlbaum.

Hong, Y.-Y., Chiu, C.-Y., Dweck, C. S., Lin, D., & Wan, W. (1999). Implicit theories, attributions, and coping: A meaning system approach. *Journal of Personality and Social Psychology*, *77*(3), 588–599. http://doi.org/http://psycnet.apa.org/doi/10.1037/0022-3514.77.3.588

Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest

and performance with a utility value intervention. *Journal of Educational Psychology*,

102(4), 880–895. http://doi.org/10.1037/a0019506

Johnson, M. L., & Sinatra, G. M. (2013). Use of task-value instructional inductions for

facilitating engagement and conceptual change. *Contemporary Educational Psychology*,

38(1), 51–63. http://doi.org/10.1016/j.cedpsych.2012.09.003

Ketelhut, D. J., Nelson, B., Schifter, C., & Kim, Y. (2013). Improving science assessments by

situating them in a virtual environment. *Education Sciences*, *3*(2), 172–192.

http://doi.org/10.3390/educsci3020172

Kuhn, D. (2003). Understanding and valuing knowing as developmental goals. *Liberal

Education*, *89*(3), 16–21.

Maehr, M. L., & Zusho, A. (2009). Achievement goal theory. In Wentzel, Kathryn R. &

Wigfield, Allan (Eds.), *Handbook of motivation at school* (pp. 77–104). New York, NY:

Routledge.

Mason, L., Boscolo, P., Tornatora, M. C., & Ronconi, L. (2012). Besides knowledge: a cross-

sectional study on the relations between epistemic beliefs, achievement goals, self-

beliefs, and achievement in science. *Instructional Science*, *41*(1), 49–79.

http://doi.org/10.1007/s11251-012-9210-0

Meece, J. L., Anderman, E. M., & Anderman, L. H. (2006). Classroom goal structure, student

motivation, and academic achievement. *Annual Review of Psychology*, *57*, 487–503.

Midgley, C., Maehr, M. L., Hruda, L. Z., Anderman, E., Anderman, L., Freeman, K. E., &

Urdan, T. (2000). *Manual for the patterns of adaptive learning scales* (Manual). Ann

Arbor: University of Michigan. Retrieved from

http://www.umich.edu/~pals/PALS%202000_V12Word97.pdf

Miller, & DeBacker, R. B. (1999). Perceived instrumentality and academics: The link to task

valuing. *Journal of Instructional Psychology*, *26*(4), 250.

Minnaert, A., Boekaerts, M., & Brabander, C. de. (2007). Autonomy, competence, and social

relatedness in task interest within project-based education. *Psychological Reports*,

101(2), 574–586.

Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary school

mathematics classroom. *Journal of Educational Psychology*, *85*(3), 424–436.

http://doi.org/10.1037/0022-0663.85.3.424

Muis, K. R., & Duffy, M. C. (2012). Epistemic climate and epistemic change: Instruction

designed to change students' beliefs and learning strategies and improve achievement.

Journal of Educational Psychology, *105*(1), 213–225. http://doi.org/10.1037/a0029690

Nelson, B. C., Kim, Y., Foshee, C., & Slack, K. (2014). Visual signaling in virtual world-based

assessments: The SAVE Science project. *Information Sciences*, *264*, 32–40.

http://doi.org/10.1016/j.ins.2013.09.011

Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience,

task choice, and performance. *Psychological Review*, *91*(3), 328–346.

http://doi.org/http://psycnet.apa.org/doi/10.1037/0033-295X.91.3.328

Pajares, F., & Urdan, T. C. (Eds.). (2006). *Self-efficacy beliefs of adolescents*. Greenwich, CT:

Information Age Publishing.

Palmer, D. H. (2009). Student interest generated during an inquiry skills lesson. *Journal of

Research in Science Teaching*, *46*(2), 147–165. http://doi.org/10.1002/tea.20263

Pintrich, P. R. (2000). Multiple goals, multiple pathways: The role of goal orientation in learning and achievement. *Journal of Educational Psychology*, *92*(3), 544–555. http://doi.org/10.1037/0022-0663.92.3.544

Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, *63*(2), 167–199. http://doi.org/10.3102/00346543063002167

Robins, R. W., & Pals, J. L. (2002). Implicit self-theories in the academic domain: Implications for goal orientation, attributions, affect, and self-esteem change. *Self and Identity*, *1*(4), 313–336. http://doi.org/10.1080/15298860290106805

Sandoval, W., & Harven, A. M. (2011). Urban middle school students' perceptions of the value and difficulty of inquiry. *Journal of Science Education and Technology*, *20*(1), 95–109. http://doi.org/10.1007/s10956-010-9237-4

Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist*, *26*(3/4), 299–323. http://doi.org/10.1080/00461520.1991.9653136

Schiefele, U. (2009). Situational and individual interest. In K. R. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 197–222). New York, NY: Routledge.

Schoenfeld, A. H. (1983). Beyond the purely cognitive: Belief systems, social cognitions, and metacognitions as driving forces in intellectual performance. *Cognitive Science*, *7*, 329–363.

Schoenfeld, A. H. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education*, *20*(4), 338. http://doi.org/10.2307/749440

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, *82*(3), 498.

Schunk, D. H., & Pajares, F. (2005). Competence perceptions and academic functioning. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 85–104). New York, NY: Guilford Press.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, *42*(1), 70.

Skinner, E., Furrer, C., Marchand, G., & Kindermann, T. (2008). Engagement and disaffection in the classroom: Part of a larger motivational dynamic? *Journal of Educational Psychology*, *100*(4), 765–781. http://doi.org/10.1037/a0012840

Stipek, D., & Gralinski, J. H. (1996). Children's beliefs about intelligence and school performance. *Journal of Educational Psychology*, *88*(3), 397–407. http://doi.org/http://psycnet.apa.org/doi/10.1037/0022-0663.88.3.397

Urdan, T., & Schoenfelder, E. (2006). Classroom effects on student motivation: Goal structures, social relationships, and competence beliefs. *Journal of School Psychology*, *44*(5), 331–349. http://doi.org/10.1016/j.jsp.2006.04.003

Usher, E. L., & Pajares, F. (2008). Sources of self-efficacy in school: Critical review of the literature and future directions. *Review of Educational Research*, *78*(4), 751–796.