ABSTRACT

Title of Document: A MODEL OF THE DEVELOPMENT OF EPISTEMIC AND ONTOLOGIC COGNITION.

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While its advocates trumpet personal epistemology research as an essential contribution to the understanding of student cognition, the field currently wrestles with four problems. There is a lack of consensus regarding construct definition, a disconnect between psychological investigations and personal epistemology's philosophical roots, a failure to integrate work from developmental psychology, and difficulties in measuring personal epistemology. This dissertation combines work from both philosophy and developmental psychology with personal epistemology research to put forth a conceptual model of epistemic and ontologic cognition that addresses these four problems while building on the strengths of past research. Development is described using four ordered positions, and is predicted to be probabilistically related to educational level. Domain-specificity is also tested in terms of ill and well-structured domains. Using both quantitative and qualitative data from a pilot study, an instrument to measure epistemic and ontologic cognition was developed. By assessing the construct validity and reliability of scores from the instrument the underlying conceptual model was tested. This instrument was administered to a sample of 662 students ranging in age from middle-school through graduate school. Results indicated that scores from the instrument had acceptable construct validity and reliability, and that a factor mixture model best represented the data, and provided mixed support for the underlying model. Educational level was probabilistically related to participants' epistemic and ontologic cognition.

A MODEL OF THE DEVELOPMENT OF EPISTEMIC AND ONTOLOGIC COGNITION.

By

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Dedication

I dedicate this dissertation to my wife, Mira Brancu, who helps me be the person I wish to be.

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I would like to thank all of the participants who endured my study, and the teachers, administrators, and professors who were so gracious with their time and support. I would also like to thank Dr. Gregory Hancock for his guidance and tolerance of my intellectual meanderings, statistical and otherwise. Dr. P. Karen Murphy provided the benevolent resistance needed to develop my epistemological muscle, while Dr. Pat Alexander has been both a muse and a sherpa, with each equally valued. My greatest gratitude goes to my advisors, Dr. Judith Torney-Purta and Dr. Roger Azevedo, who have struggled to leave the lines on my soul necessary to prepare me for this dissertation and my career ahead. I am indebted to you for all you have done, and hope to continue to act in ways that develop and extend the lessons you have taught me.

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CHAPTER 1: INTRODUCTION

If education were simply a matter of transmitting knowledge from the learned to the learner, it would be at best a logistical problem. However, education is not merely an exchange of knowledge from professor to student, but rather a constructive process where individuals come to know in their own ways, and what is taught is influenced by their prior experiences and beliefs (Phillips, 1995). Alexander and colleagues (1998) emphasize that "often unvoiced theories, beliefs, or biases that may unwittingly penetrate the soul of the educational enterprise" (p. 97) can have a tremendous influence upon what is learned. Indeed, they claim, "one of these quiet but powerful frameworks is the epistemological beliefs that students…hold" (Alexander, Murphy, Guan, & Murphy, 1998, p. 97). Educational psychologists describe epistemological beliefs as "beliefs we hold about knowledge and knowing" (Hofer, 2000, p. 3) that can influence students' construction of knowledge. Psychologists have adopted the term "personal epistemology" to describe how individuals think about knowledge, and how these beliefs influence their learning and understanding of the world. This area of research has its roots in philosophical epistemology, a branch of philosophy that examines what knowledge is, and how it can be established (Pollock & Cruz, 1999; Williams, 2001).

Both philosophical epistemologists and psychologists study how individuals discriminate between knowledge and other kinds of beliefs, intuitions, and speculations. Philosophical epistemologists have long been fascinated by the question of what constitutes knowledge qua knowledge, as opposed to other kinds of beliefs (Pollock & Cruz, 1999; Williams, 2001). Most philosophers define knowledge as justified true belief, and seek the sufficient justifications for elevating a belief to the status of knowledge.

Other philosophers question whether it is even possible to have sufficient justification to claim knowledge, a stance called skepticism (Given the varied terminology of the field as well as this dissertation's reach into three separate research areas, personal epistemology, developmental psychology, and philosophy, a glossary is provided after the appendices of this dissertation). Epistemological inquiry is generally restricted to more-or-less objective claims about the world, such as whether one can *know* that a fire truck is red. Issues of morality and aesthetics are generally viewed as outside the realm of philosophical epistemology because it is difficult to justify claims of this type as "true" or "right" (Pollock & Cruz, 1999).

Psychologists are not interested in any "right" way to establish justification. Rather, psychologists are intrigued by the many ways in which individuals think about knowledge, and how those beliefs about knowledge influence learning (Hofer & Pintrich, 1997). These epistemological beliefs can influence how a student both constructs and uses knowledge. For example, people will act in ways that are congruent with their knowledge, and are less likely to abandon knowledge claims in the face of competing evidence (Alvermann, Smith, & Readence, 1985). Therefore, students' beliefs about what is and is not knowledge can play a powerful role in what and how they learn.

Personal epistemology researchers have also examined people's beliefs about knowledge's characteristics in general. For some, knowledge is a simple collection of facts, whereas for others it is more like a web of related concepts. Some people may believe that only those things that are unchanging can be considered knowledge, whereas others may believe knowledge is dependent upon context (Schommer, 1990; Williams, 2001). In essence, people can have beliefs about the nature and structure of knowledge.

These beliefs about knowledge's character can influence how people decide what claims are and are not worthy of being considered knowledge. Personal epistemology researchers assert that learners' core beliefs about the nature of knowledge and knowing influence both how they go about learning and what they are capable of understanding (Hofer, 2004a; Hofer & Pintrich, 1997, Schommer, 1990). They claim that certain beliefs about knowledge and its nature are more availing (Muis, 2004), or helpful, than others, particularly in the college years when the subject matter of learning becomes dense and complex and students have less help from others in structuring the knowledge they are expected to learn.

Thus, on the one hand there are philosophers studying epistemology to determine the criteria by which knowledge can be discriminated from belief. On the other hand there are psychologists who are studying all the different ways people think about knowledge and knowing, and how those beliefs influence learning. However, before the relations between these two fields can be examined, another more important question must be asked. How relevant is all of this work to the actual processes of learning?

The Importance of Epistemology to Learning

Although usually somewhat vaguely stated, almost every research article in the field of personal epistemology begins with some description of how important the research is to understanding how students learn. Psychologists claim the study of personal epistemology is important because it will "help us better understand the teaching and learning processes in classrooms" (Hofer & Pintrich, 1997, p. 133). King and Kitchener (2002) wrote:

> The theoretical foundation…is grounded in two major assumptions, that students' understanding of the nature, limits, and certainty of knowledge affects how they

> approach the process of learning, and that their epistemic assumptions change over time in a developmentally related fashion. (p. 55)

Schommer-Aikins and Easter (2006) also highlight the perceived importance of personal epistemology research: “Bear in mind that the study of personal epistemology is important because it is likely that it plays multiple roles in students’ learning and problem solving” (p. 412). Kuhn (2005) states that students who do not progress beyond absolute ideas of right and wrong will see “little point to expending the mental effort that the evaluation of claims entails” (p. 32). Beyond education, Kuhn and colleagues (Kuhn, Weinstock, & Flaton, 1994) have shown that jurors’ level of epistemological understanding is related to their ability to assess alternative verdict choices and ultimately their level of reasoning about cases. Yet there currently exists more theory than research regarding exactly how personal epistemology influences learning and thinking.

The suggestion in most work on personal epistemology is that naïve personal epistemologies handicap learning by limiting a student’s ability to fully grasp the complexity and interconnectedness of knowledge. A simple example would be college students who struggle in history classes because they believe every question in the content area has a definite answer (VanSledright & James, 2002). These students may struggle to grasp questions of subjectivity, narrative, and sourcing in history because they have a more basic belief about knowledge that is getting in the way: the belief that the world, particularly its past, can be objectively known. Students who see all knowledge as factual would have little incentive to critically examine their own interpretations or those of others.

This issue has recently received national attention after the passing of a Florida state law that declared, “American history shall be viewed as factual, not constructed, shall be viewed as knowable, teachable, and testable” (Florida Education Omnibus Bill, H.B. 7087e3). Historians and teachers have been concerned about this law specifically because it suggests that history is composed of facts, and that one need not consider alternative interpretations of those facts. Thus, students are being taught to have a simplistic view of historical knowledge, wherein interpretation and justification are not relevant. As one teacher put it, “If you just require students to memorize information, that’s not the best way to create active citizens...we’re just creating little robots” (History News Network, 2006).

Thus, one of the main concerns of educators is that a failure to develop a more sophisticated personal epistemology than that implied in the Florida bill will leave students without the skills necessary to make good judgments about knowledge claims both in and out of school. Some educational psychologists believe that a better understanding of students’ personal epistemologies will point the way toward interventions designed to help those students adopt more beneficial beliefs. Those more availing beliefs, in turn, will then allow for more sophisticated learning and evaluation of knowledge claims (Hofer & Pintrich, 1997).

Early Theories of Personal Epistemology

One of the first people to examine people’s personal epistemologies was Perry (1970, 1999). He interviewed college students at Harvard regarding their beliefs about knowledge, and found that in general students fell into one of four groups. Dualists saw the world in black or white, right or wrong terms, and had complete trust in authority figures’ ability to provide knowledge about the world. Multiplists had lost faith not only in authority figures, but also in the possibility of knowledge. These students felt there were no "truths" and that knowledge did not exist. Instead, every person's opinion was equally valid. Perry used the term relativists to describe those that progressed beyond this stage. Relativists acknowledged that absolute knowledge might not be possible, but that criteria could be used to judge the probability of knowledge claims being true. Finally, the last position in Perry's model was commitment to relativism, where the student chose a set of criteria to use to judge knowledge claims, while acknowledging that others might choose different criteria. What made Perry's work so intriguing was that he claimed a majority of students entered college as dualists, and few made progress past multiplicity before graduating.

Perry's claims regarding the naiveté of college students raised numerous questions, including whether incoming freshmen were adequately prepared to think in the relativistic ways their professors expected. The predominance of multiplistic thinking in college seniors also called into question why the college experience was not more effective in nurturing mature thinkers. These concerns, among others, led to over 30 years of research into what has come to be known as the field of personal epistemology, or how students think about knowledge.

Studying Personal Epistemology

Today, there is much interest in personal epistemology, yet the field continues to be quite fragmented, with varying definitions and models of students' beliefs about knowledge and knowing. For example, in one of the first comprehensive reviews of the literature on personal epistemology, Hofer and Pintrich (1997) wrote

> In all this research there is very little agreement on the actual construct under study, the dimensions it encompasses, whether epistemological beliefs are domain specific

> or how such beliefs might connect to disciplinary beliefs, and what the linkages might be to other constructs in cognition and motivation. (p. 89)

Five years later, this well-received journal article lead to a book on personal epistemology, also edited by Hofer and Pintrich. The introductory chapter of that book stated:

> In providing updated looks at each of the five main models of personal epistemology, we hope that the reader will be able to gain perspective on both their commonalities and their differences, and to engage questions that have concerned those doing research in this field. First and foremost, are these researchers addressing the same construct…is it worthwhile or possible to consolidate the theoretical work that has developed in this area? How might we achieve greater conceptual clarity? (Hofer, 2002, p. 6)

Two years after the publication of this book, a special issue of the journal *Educational Psychologist* was published, solely devoted to personal epistemology. In that issue, Hofer (2004a) stated "the existing research programs lack a unifying terminology" and that the goal of the issue was to "sharpen the conceptual understanding of personal epistemology" (p. 1). In the same issue, Bendixen and Rule (2004) stated, "Currently there is neither a unified model of epistemological understanding to guide research, nor a single model that clearly articulates the relationship between personal epistemology and how epistemological beliefs change and develop" (p. 69). An examination of recent articles on the topic reveals researchers continuing to dialogue about what should and should not be considered "personal epistemology" (e.g., Schommer-Aikins & Easter, 2006).

Thus, almost ten years after the call for at least more definitional clarity, if not some integration of disparate models, the field of personal epistemology remains fragmented and difficult to follow, with authors using different terminology and disagreeing at a fundamental level regarding the very constructs to be studied. For example, there continues to be a debate as to whether personal epistemology is a unidimensional or a multidimensional construct, and whether the phenomenon is domain-general or domain-specific (see Pintrich, 2002, for a discussion of both of these issues).

At least each of these models uses a common word: epistemology. Unfortunately, even the appropriateness of this term has been called into question. Kitchener (2002) in particular has taken the field to task for sloppy operational definitions. He points out that the definition of "epistemology" is literally translated as the *study or theory of knowledge*. Therefore, to suggest that students have a "personal epistemology" is akin to saying that college students are philosophers, studying how knowledge can be justified. It is unlikely that personal epistemology researchers intend this. Other confusing terms include "epistemological beliefs" (Schommer-Aikins, 2004), which is literally translated as beliefs about the study of knowledge, and "epistemological theories" (Hofer & Pintrich, 1997) which, taken literally, means "theories about the theory of knowledge." In addition, there is also concern with the use of the term "availing" (Muis, 2004) to characterize more "sophisticated" or "advanced" kinds of epistemic cognition. Availing may not be the most accurate description as it is not clear that the most "advanced" beliefs are helpful in every situation. Cognitive flexibility theorists (Feltovich, Spiro, & Coulson, 1997) suggest that the demand characteristics of the situation may dictate whether a more complex or simplistic view is most helpful. Therefore, it may be most accurate to describe more "advanced" beliefs in personal epistemology as "adaptive" (Dr. P. Karen Murphy, personal communication, May 11, 2007).

In the strictest sense, these terms do not adequately convey their authors' meanings. There is a tremendous difference between having beliefs about knowledge and studying them, but these terms conflate the two. This is not merely a semantic issue. As I will show, the failure to clarify the terminology in personal epistemology research is a symptom of a greater problem, namely that psychological work in personal epistemology has borrowed the language, but not the lessons, of philosophers (Buehl & Alexander, 2001). A closer reading of the philosophical work in epistemology can help clarify not only the terminology used in personal epistemology research, but also the constructs that should be included in this area of study. It may also be able to shed some light upon the degree of domain-generality versus specificity in personal epistemology.

Developmental psychology theorists (Chandler, Hallett, & Sokol, 2002) have also criticized the current models and findings of personal epistemology research. In particular, they claim that most personal epistemology work has focused too much on college students and ignored important research regarding children's theory of mind (e.g., Chandler, Boyes, & Ball, 1990; de Rosnay & Hughes, 2006; Flavell, 2004; Flavell, Flavell, Green, & Moses, 1992; Krettenauer, 2004). This research contributes to the discussion by debunking the findings of personal epistemology researchers who claim that incoming college freshmen see the world solely in objective, black and white terms. There is a great deal of developmental psychology research demonstrating that college students, as well as much younger children, do in fact think in more subjective ways than researchers such as Perry would expect.

For example, theory of mind researchers have found that teenagers are able to articulately argue both sides of the debate about the legal driving age (Boyes & Chandler, 1992), and that young children understand that cats like cat food but humans do not (Flavell, Flavell, Green, & Moses, 1992). Yet, Chandler and colleagues (2002) correctly note, “almost no one who writes about the epistemic development of college students gives any indication of also having read the literature on children’s so-called theories of mind” (p. 157). The irony here is that this critique came about in a chapter in Hofer and Pintrich’s 2002 book on personal epistemology, and yet it still has not received much attention. Nonetheless, I believe that any model of personal epistemology must be able to align with the research findings within the theory of mind literature, and at this point none do so, with perhaps the exception of Kuhn and Weinstock (2002) who allow for the possibility of more sophisticated epistemic cognition in populations younger than college age.

Finally, in addition to these concerns, the field of personal epistemology continues to struggle with measurement (Pintrich, 2002). Qualitative methods for measuring personal epistemology are time-intensive and often utilize data collection and analysis protocols with relevance only to a specific model, making it difficult to determine whether they have any validity outside of their narrow research context. Quantitative measures of both personal epistemology as well as theory of mind have been plagued with concerns regarding their reliability and validity (Clarebout, Elen, Luyten, & Bamps, 2001; Hallet, Chandler, & Krettenauer, 2002; Wood & Kardash, 2002). Concerns about whether personal epistemology should be measured at the domain-general or domain-specific level are also relevant here (Buehl & Alexander, 2001, 2005; Buehl, Alexander, & Murphy, 2002). Thus, it is not hyperbole to say that the field of personal epistemology is in something like a quagmire, with major controversies regarding construct definition, scope, terminology and measurement.

Purpose and Significance of this Dissertation

Given the strong level of interest in personal epistemology research, this dissertation addressed the concerns of authors both within and outside of the field of educational psychology. Researchers in personal epistemology have frequently lamented that the various models in the field seem to have significant overlap. Nonetheless, these models have yet to be satisfactorily integrated due to both terminology differences and researcher intransigency (Hofer & Pintrich, 1997; Pintrich, 2002). The focus of personal epistemology might be more clearly defined if researchers attended more to the work of philosophers. Buehl and Alexander (2001) as well as Murphy (2003) are psychologists who have attempted to do this. In addition, evidence from theory of mind research (Chandler et al., 2002; Flavell, 2004) suggests that the models within personal epistemology must be incomplete if they cannot explain epistemic cognition in students younger than traditional college age. Finally, there remain problems regarding the psychometric qualities of measures of personal epistemology. Aside from technical concerns regarding the actual items used to measure the constructs, there are fundamental conceptual questions such as whether personal epistemology is domain-general or domain-specific, and if it is domain-specific, at what level of specificity? It is not surprising that measures that ignore these controversies have weak psychometric properties.

I suggest that a new model must be advanced to address these concerns. The model must have a solid, interdisciplinary conceptual foundation, drawn from the work of philosophers, developmental psychologists, and educational psychologists. With such a foundation, attempts to measure the constructs within the model will be more likely to have strong psychometric properties, as well as to provide evidence regarding the domain-generality or specificity of students' beliefs about knowledge upon which research and teaching practice can be based.

The Conceptual Model of Epistemic and Ontologic Cognitive Development

In this dissertation, I theoretically derived and empirically investigated a new conceptual model of students' beliefs about knowledge. This conceptual model combines the numerous models of personal epistemology with the thinking of philosophers and the findings of developmental psychology researchers. In addition, it addresses a major problem found in both educational psychology and developmental psychology: the measurement of these constructs (Pintrich, 2002). By integrating philosophical epistemology and theory of mind research with personal epistemology, I could more clearly and accurately define the phenomenon of students' beliefs about knowledge and their development, leading to more reliable and valid means of measuring those constructs. In addition, I provided empirical evidence regarding the issue of domain-generality versus specificity by examining students' beliefs about knowledge within two domains. My conceptual model is tentatively entitled the Epistemic and Ontologic Cognition Development Model (EOCDM).

Briefly, my conceptual model addresses both epistemic and ontologic cognition because I believe the two areas are confounded in current research. Epistemic cognition is thinking about knowledge and knowing. Ontologic cognition, on the other hand, concerns individuals' understanding of reality. Ontology is the study of existence, and the basic categories and relationships that define that existence (Teichman & Evans, 1995). Many models of personal epistemology, including the work of Schommer (1990) and Kuhn and

Weinstock (2002), include individuals' beliefs about whether knowledge is simple or complex, and certain or changing. These questions are not epistemological; they are ontological, having to do with characteristics of objects in the world. A simplistic ontological view is that external objects are fixed and separate entities, and knowing about them requires only a list of their qualities, with the belief that this list will never change regardless of time or context. Models of personal epistemology that define these beliefs as epistemological make a definitional error as well as a conceptual one. My model categorizes these beliefs as ontological and separate from epistemological ones, allowing for more flexibility in describing how individuals view both knowing and knowledge itself, as well as providing a stronger conceptual foundation for the creation of a measure of this model.

A Measure of Epistemic and Ontologic Cognition

A pencil-and-paper survey measuring the constructs in my model of epistemic and ontologic cognition was developed. This survey was informed by past research into personal epistemology, philosophy, and work from developmental psychology, specifically the theory of mind. Issues concerning the survey included whether to use items from other pencil-and-paper measures of personal epistemology, how to address concerns about domain-generality and specificity, and whether to include a measure of Piaget's (1972) theory of cognitive development with the survey.

Items From Other Personal Epistemology Measures

Schommer's (1990) Epistemological Questionnaire (EQ) is the most commonly used paper-and-pencil measure of personal epistemology. Variants of this measure exist, but the only one to receive significant attention is the Epistemic Belief Inventory by

Schraw and colleagues (Schraw, Bendixen, & Dunkle, 2002). Numerous researchers have expressed concerns about the reliability and validity of both of these measures (Clarebout et al., 1998; Greene, Azevedo, & Hancock, 2006; Wood & Kardash, 2002). These concerns, plus the differences in the conceptual model underlying these other measures as compared to the one for this dissertation, precluded using them in this dissertation. However, individual items from these measures were examined for possible inclusion in the measure for my conceptual model.

Domain-Generality and Domain-Specificity

The issue as to whether epistemic cognition is domain-general or domain-specific remains a controversial one in the field (Buehl & Alexander, 2001, 2005; Buehl, Alexander, & Murphy, 2002; Hofer & Pintrich, 1997). Most unidimensional models of personal epistemology advocate for domain-generality, or independence. King and Kitchener (2004), for example, continue to claim moderate to strong domain-independence in their model. Schommer and Walker (1995) also provide empirical evidence for the domain-generality of the constructs in their model.

While Hofer (2000) found evidence predominantly supporting the domain-generality of her epistemological theories, there was some indication of separate domain-specific beliefs as well. Buehl, Alexander and Murphy (2002) created a survey of epistemological beliefs in mathematics and history, and used confirmatory factor analysis to evaluate models positing both domain-generality and specificity. They found that the model allowing for domain-specific beliefs had the best fit, but allowed that correlations between the factors suggested the presence of overarching domain-general beliefs as well. This finding was bolstered by the work of Buehl and Alexander (2005) who found that, using cluster analyses, epistemological beliefs grouped into interpretable profiles within domain, and that when these profiles were characterized as sophisticated or not, that participants' profiles across domains were statistically significantly correlated. Students tended to have a similar level of sophistication across history and mathematics, suggesting the possibility of a superordinate domain-general epistemological belief. Within the theory of mind literature, Chandler and colleagues (2002) have also suggested the possibility that both domain-specific and general epistemological beliefs work in concert, for example with an overarching skepticism of authority mitigated by trust in the work of natural scientists.

Thus, many of the major models of personal epistemology (Baxter Magolda, 2004; King & Kitchener, 2004; Perry, 1970; Schommer & Walker, 1995) covered in this dissertation advocate for domain-generality, yet recent research and models suggest that students' beliefs about knowledge have domain-general and specific aspects (Buehl & Alexander, 2001, 2005; Buehl, Alexander, & Murphy, 2002; Chandler et al., 2002). It would therefore seem important to assess the domain-generality or specificity of the constructs within my conceptual model. Therefore, to allow for such an investigation, my measure included similarly worded items for two academic domains. I predicted that domain-specificity would be found, and empirically tested that hypothesis through factor analysis methods similar to those used by Buehl and colleagues (2002).

Measures of Piaget's Formal Operations

Finally, given that my model builds off of work from developmental psychology (Chandler et al., 2002; Hallet et al., 2002), and the fact that many of those models claim that advanced epistemic cognition is not possible until Piaget's (1972) stage of formal operations, the inclusion of a measure of Piaget's theory was considered. Unfortunately, paper-and-pencil measures of formal and concrete operations suffer from problems of reliability, validity, and excessive length (Patterson & Milakofsky, 1980; Pratt & Hacker, 1984; Santmire, 2004; Stefanich, 1983), thus precluding their use in this dissertation. This is clearly not a current area of measurement development. This resulted in an inability to disentangle the potentially confounding influences of age, cognitive ability, and experience with academic domains. Future research will be required to investigate these phenomena and their influence upon epistemic and ontologic cognition.

Summary

To measure the constructs in my model, I created the Epistemic and Ontologic Cognition Questionnaire (EOCQ), with items assessing student beliefs in multiple academic areas. The design of this instrument took into account research in psychology and philosophy, as well as built upon the work of other quantitative instruments and research findings from the field of personal epistemology. The measure was written such that a test of domain-specificity could be performed, in the hopes of providing additional evidence regarding this controversy. However, *a priori* attempts to make an instrument capable of adequately assessing my model and the domain-specific hypothesis were also bolstered by a pilot study that was conducted, and revisions based upon the results of this pilot were made.

Pilot Study and Measure Revision

A pilot study was conducted to examine participants' interpretations of my measure of epistemic and ontologic cognition, the EOCQ. Thirteen participants completed the measure while thinking aloud, or verbalizing their thoughts. They were also asked specific questions after completing the measure. Participants were audiotaped and transcripts of these recordings were created to assess the measure and modify the items as needed. Major findings were that middle-school students could only understand items in regards to two of the four academic domains, and that while in general the participants responded as expected to many items, numerous items did require revision. In addition, an examination of literature concerning folk understandings of words such as “knowledge” informed the language used in the final dissertation version of the EOCQ

Middle-school students had no background knowledge regarding physics and political science. One student simply could not speculate as to what these domains might include, whereas the other two guessed incorrectly. As such, these domains were dropped from the EOCQ because the same instrument and items must be used with each age group if comparisons are to be made. This left mathematics and history as the academic domains to be investigated.

In the final version of the EOCQ, a majority of the items from the pilot version were revised in some way. Some of the revisions were fairly minor, such as rephrasing negatively-worded items from “I don’t automatically believe everything I learn in math class” to “I believe everything I learn in math class.” Other items on the pilot clearly were interpreted differently than intended, such as “To do well in math class, the main thing you need to do is memorize facts.” This item was supposed to tap whether participants recognized that there is a constructivist aspect to mathematics. However, numerous pilot participants disagreed with this statement not because they believed in constructivism in mathematics, but because they thought formulas were different than facts, and were just as important. Therefore, this item was changed to read “To know math well, you need to memorize what you are taught." This item better measures whether individuals believe that knowledge in mathematics is simple, requiring only memorization, or whether mathematics knowledge requires deeper processing.

The language of the items was also examined more closely. Alexander and colleagues (Alexander & Dochy, 1995; Alexander et al., 1998) have found evidence that individuals from high-school students through faculty members have implicit definitions of "knowledge," and that these definitions differ in some ways from other terms such as "beliefs." In general individuals most often described these two concepts as having significant but not total overlap, with knowledge seen as more objective and beliefs as more subjective, but no less important. Knowledge was most often defined using terms such as "know" and "facts" whereas definitions of beliefs most often included the words "believe," "true," and "values." Given these findings, it was important that the survey instrument utilize terms more associated with knowledge, and not beliefs. As such, in the final dissertation version of the EOCQ, the terms "true" and "truth" were removed from many of the pilot items.

A more complete description of the pilot and subsequent changes made to the final dissertation version of the EOCQ can be found in Chapter 3.

Hypotheses and Research Questions

With this dissertation I sought to investigate the epistemic and ontologic cognition of students in middle-school through graduate school. The first step was the creation and administration of the EOCQ, which was designed to measure the constructs in my proposed conceptual model (the EOCDM). The viability of my EOCDM was examined through testing the reliability, construct validity, and discriminant validity of scores from the final, post-pilot, version of the EOCQ. I used a factor mixture statistical model to investigate these claims, which tested both the validity of the conceptual model as well as whether the proposed developmental sequences were supported by the data. In addition, this technique allowed an investigation of the controversy regarding domain-generality versus specificity.

Specifically, my first hypothesis was that there are three latent constructs that comprise epistemic and ontologic cognition, and that the items in the EOCQ would adequately capture these constructs. I also hypothesized that these constructs are not strictly domain-general or specific, meaning that in the statistical model separate factors for these three latent constructs were needed for both ill and well-structured academic areas, such as history and math respectively (Frederiksen, 1984). I also predicted that scores from my measure would be reliable.

Assuming that the EOCQ adequately captured the three latent factors within each domain, I next hypothesized that students' scores on these latent factors, within domain, would fall into one of four predictable patterns, or positions as they are called within the conceptual model. In the conceptual model, students progress through these positions in a specific order: first realism, then either dogmatism or skepticism, followed by rationalism. This progression through the positions of model is hypothesized to begin sooner for ill-structured domains (Frederiksen, 1984), such as history, than for well-structured domains, such as mathematics. This difference in progression has been supported by previous research into children's theory of mind (Hallet et al., 2002).

By using a factor mixture approach with a single latent categorical factor for both mathematics and history position, the statistical model tested whether the scores on all six latent factors supported these positions. While only a longitudinal study ranging over several years could fully test the developmental aspect of the conceptual model, this cross-sectional dissertation can present initial evidence of the model's adequacy. Because my conceptual model states that an individual's EOCDM position in mathematics should be no higher than that individual's position in history, the participants' predicted positions in both domains, using the factor mixture statistical model, was examined to test this hypothesis.

Finally, I hypothesized that educational level would predict EOCDM position, as most personal epistemology models suggest that exposure to educational experiences is positively correlated with more adaptive beliefs (Buehl & Alexander, 2001). The specific research questions and hypotheses necessary to test these claims were as follows:

Research Question: What evidence is there supporting or refuting the EOCDM based on the construct and discriminant validity and reliability of scores from the EOCQ?

Hypothesis 1: The statistical measurement model, which allows all latent factors (simple and certain knowledge, justification by authority, and personal justification dimensions) to covary, will have an acceptable level of data-model fit according to Hu and Bentler's (1999) criteria.

Hypothesis 1a: The construct reliability of latent factor scores derived from the measurement model will have a Coefficient *H* value greater than or equal to .7.

Hypothesis 2: Domain-specificity will be found, with items for history and mathematics loading on separate latent factors.

Hypothesis 3: The hypothesized factor mixture statistical models will have an acceptable level of data-model fit. The fit of these statistical models will be compared to alternative factor mixture statistical models positing more positions, as well as ones positing fewer positions, as well as models with less restrictive assumptions. Procedures and criteria for factor mixture model fit as outlined by Lubke and Muthén (2005) will be used.

Hypothesis 3a: The construct reliability of latent factor scores derived from the factor mixture model will have a Coefficient *H* value greater than or equal to .7.

Hypothesis 4: For a majority of individuals, their conceptual model-predicted EOCDM position within history will be equal to or higher than their conceptual model-predicted position for mathematics.

Hypothesis 5: Educational level and EOCDM positions in history and mathematics will be probabilistically related, with higher levels of education predictive of higher positions within the EOCDM.

CHAPTER 2: LITERATURE REVIEW

The model I am proposing draws upon the work of numerous other researchers. As such, it is important to clearly review the literature to illustrate both how my model builds upon this work as well as how it makes a new contribution. However, nomenclature varies across researchers and fields of study. Researchers use terms such as "personal epistemology" (e.g., Perry, 1970, 1999), "epistemological beliefs" (e.g., Schommer-Aikins, 2004), and "epistemological theories" (e.g., Hofer & Pintrich, 1997). This difference in language can be confusing, but for the most part each term comes from a common core of ideas regarding individuals' beliefs about knowledge.

To promote clarity through consistency, I will adopt the following terminology conventions. When discussing the work of educational psychologists in general, I will refer to the area as personal epistemology. This is consistent with the terminology used by Hofer and Pintrich in their 2002 book as well the special issue of *Educational Psychologist* that Hofer (2004a) edited. When reviewing the work of specific authors in this tradition, I will utilize their terminology. For example, Schommer-Aikins (2004) uses the term "epistemological beliefs" so I will refer to her model as such. The philosophical literature is more consistent in utilizing the term epistemology, and I will follow that convention. Finally, when referring to my own model, I will use the term Kitchener (2002) recommends: epistemic cognition. My model reclassifies certain aspects of personal epistemology as ontologic cognition, as well.

This literature review covers numerous approaches to the study of epistemic cognition, and the first of these can be loosely classified as unidimensional or monolithic models including the work of Perry (1970, 1999), King and Kitchener (2004), Baxter

Magolda (2004), and Kuhn (Kuhn, Cheney, & Weinstock, 2000). These researchers view personal epistemology as a single construct. The work of Schommer-Aikins (2004) and Hofer and Pintrich (1997) can be classified as multidimensional models, suggesting there are numerous independent dimensions, or factors, that comprise an individual's personal epistemology. Disagreements persist amongst these researchers, and I believe a closer look at the philosophical study of epistemology can help resolve these disagreements. A full review of the philosophical literature is well beyond the scope of this dissertation. However, a solid understanding of how philosophical thought can inform psychological work can be reviewed relatively briefly. Finally, I include developmental psychology literature regarding theories of mind and developmental differences before outlining my own model.

Thus, this literature review seeks to bring together work from educational psychology, philosophy, and developmental psychology to better understand epistemic cognition. I believe the integration of work from each of these fields leads to a more complete model that can both accommodate the disparate findings of the authors mentioned previously as well as resolve some long-standing disagreements regarding the definition, development, and measurement of epistemic and ontologic cognition.

Inclusion and Exclusion Criteria

The field of personal epistemology is growing quite quickly, and seems to currently be a focus of numerous educational researchers (Hofer, 2004a). However, with any burgeoning area of research, interest brings a proliferation of models, studies, and viewpoints regarding the construct itself as well as its relations with other constructs of interest. Yet, personal epistemology research continues to struggle with construct definition and scope (Hofer & Pintrich, 1997; Kitchener, 2002). Given the somewhat broad scope of literatures reviewed here, it is important to clearly identify the criteria by which models and studies were chosen for inclusion in this dissertation (Boote & Beile, 2005).

The models of personal epistemology reviewed include those considered most prevalent in the field. The choice to include Perry's (1999) model is an easy one, as it is widely considered the basis of the field itself (Hofer & Pintrich, 1997). From Perry's work, numerous models have sprung. These models, such as King and Kitchener's (2004), Baxter Magolda's (2004), and Kuhn's (Kuhn, Cheney, & Weinstock, 2000) are included because they are the ones most frequently mentioned in reviews of the area. Hofer and Pintrich's (1997) influential review of personal epistemology covered each of the models mentioned previously in detail, and their subsequent 2002 book included chapters by each of the researchers as well. In addition, a recent special issue of *Educational Psychologist* (2004) included chapters by all of the aforementioned authors except Kuhn (see Table 1 for a comparison of these models).

Table 1

Comparison of models of personal epistemology

Age	*Perry's Intellectual and Ethical Development*	*Baxter-Magolda's Epistemological Reflection*	*King & Kitchener's Reflective Judgment*	*Kuhn's Argumentative Reasoning*[a]
0 to 4	Dualism	Absolute Knowing	Prereflective thinking	Realist
4 to Mid adolescence	Dualism	Absolute Knowing	Prereflective thinking	Absolutist
Mid adolescence to Early College	Dualism	Absolute Knowing	Prereflective thinking	Multiplist
Early to Late College	Multiplicity	Transitional Knowing	Quasireflective thinking	Multiplist
Post-College	Relativism	Independent Knowing	Quasireflective thinking	Evaluativist[b]
Graduate School	Commitment within Relativism[b]	Contextual Knowing[b]	Reflective thinking[b]	Evaluativist[b]

Adapted from Hofer & Pintrich (1997)
[a] Kuhn's model varies across different domains, the general pattern is shown here
[b] Most models concede that only a relatively small percentage of adults ever achieve these levels of development

Schommer-Aikins's (2004) model of epistemological beliefs has also been quite important, appearing in the aforementioned reviews, books, and special issues. In addition, her model is distinct from the others, positing independent dimensions of personal epistemology, as opposed to the more monolithic or unidimensional models of Perry, King and Kitchener, Baxter Magolda, and Kuhn. Schommer-Aikins was also one of the first to create a pencil-and-paper measure of personal epistemology (Schommer, 1990) and her instrument, or variants of it, has been used in countless studies since then. This quantitative approach to measuring personal epistemology is distinct from the interview-based, qualitative measures used by the other researchers cited previously, and has both its strengths as well as its challenges. Hofer and Pintrich (1997; Hofer, 2004b) attempt to both redefine the parameters of the construct of personal epistemology as well as encompass many of the aforementioned models, thus it is important to review their model here.

Unfortunately, all of these researchers have struggled with the measurement of personal epistemology (Wood & Kardash, 2002). For the most part, qualitative approaches have been used to measure the unidimensional personal epistemology models. These studies have often involved interview methods with thick description of those interviews, with some research programs spanning up to 25 years (Baxter Magolda, 2004; King & Kitchener, 2004). While rich in detail, these studies have not connected personal epistemology to other aspects of education, short of describing how students struggle with the complexity of learning at the collegiate level. Therefore, given both the relatively narrow reach of these models into the rest of educational research literature as well as my belief that the models themselves do not adequately capture the construct, I will only cover a selection of studies by these authors. Instead, I will focus upon describing the models and how they inform my work.

I have also decided to limit my review of Schommer-Aikins's (2004) model to a select number of studies. Schommer-Aikins's model, due to both its compelling nature and the quantitative measure's ease of administration, has spawned a wealth of studies by both the Schommer-Aikins and other researchers. Some of these studies have focused on validating measures of the model, and others have attempted to demonstrate relations between the model and other educational psychology constructs of interest such as self-efficacy (Greene, Azevedo, & Hancock, 2006) and self-regulated learning (Paulsen & Feldman, 2005). However, there are concerns regarding the reliability and validity of scores from Schommer-Aikins' instrument (see Clarebout et al., 2001; Schraw, Bendixen, & Dunkel, 2002; Wood, Kitchener, & Jensen, 2002). Therefore, my coverage of studies utilizing Schommer-Aikins's model and measures will be limited to those that have as their primary purpose the clarification of the model and the investigation of those measures. Studies that assume that Schommer-Aikins's model and measures are sufficiently validated (e.g., Paulsen & Feldman, 2005) will not be reviewed.

Given that an accurate operational definition of the construct is still a contested issue, I will review the philosophical literature on epistemology to help clarify meanings and the scope of the discussion. While a thorough treatment of all of the variants of epistemological theorizing is beyond the scope of any review in educational psychology, how philosophers outline the scope and limits of epistemology can help with definitional issues in the educational psychology literature (Hofer & Pintrich, 1997). In addition, philosophical thinking regarding the central questions of epistemology will prove helpful in supporting my decision to focus my psychological investigation of epistemic cognition upon justification, a process that has received relatively little attention compared to other dimensions within the psychological literature.

My forays into literature beyond educational psychology also extend into developmental psychology work on the theory of mind. Chandler and colleagues (2002) have convincingly established the importance of integrating personal epistemology and theory of mind research. Again, a thorough summary of the vast theory of mind literature would require its own full literature review. However, I will summarize this work in preparation for both an explanation of how it helps integrate the aforementioned personal epistemology models as well as how I believe the philosophical literature can be used to elucidate the measurement of Chandler's model, which to this point has proven difficult (Hallet, Chandler, & Krettenauer, 2002).

Thus, the criteria for inclusion and exclusion of studies within this review were based on the need to provide theoretical and philosophical support for a new model of epistemic and ontologic cognition tested in this dissertation. Although empirical research is included, it is not a focus of this review. Instead, my goals are to outline current problems in the field concerning the definition the construct, the scope of its influence, how epistemic cognition develops, and the problems researchers have had measuring the construct and its development, including the issue of domain-generality versus specificity. I then use key aspects of each area of literature I review to present my own model, in an attempt to both clarify previous problem-areas in the field as well as provide new directions for research and understanding. I turn first to a review of Perry, and the models that most closely follow his work.

Unidimensional Models of Personal Epistemology

William Perry's Scheme of Intellectual Development

Perry (1999, 1970) developed one of the first models of students' beliefs about the nature and origins of knowledge. Perry intentionally called his model a "scheme," and termed each division of it a "position" rather than the more common term "stage." This choice of nomenclature reflected Perry's belief that students' development was dynamic, and their positionality toward knowledge in a constant state of flux, with only occasional periods the could loosely be considered "stages." Based on interviews with mostly male

Harvard students conducted in the 1960s, Perry and his colleagues developed a model of intellectual development with four main positions: dualism, multiplicity, relativism, and commitment to relativism.

Dualists see the world in terms of absolutes (Perry, 1999). Statements are seen as being either right or wrong, with authority figures as the conveyors of knowledge. Through hard work and obedience, the dualist believes knowledge can be acquired. The dualist clings to the belief that knowledge is factual. Students transitioning between dualism and multiplicity acknowledge that authority figures can disagree, but believe that those disagreements are either due to confusion or the fact that some key piece of knowledge has not been discovered yet. The multiplicist has lost faith in authority and knowledge in general, claiming that all beliefs are equally valid and impossible to either substantiate or refute. For the multiplist, there are no authority figures. In transitioning to relativism, the student sees knowledge as contextualized, with subjective but defendable standards established for evaluating knowledge claims, and these standards may vary across people or groups. Thus, the relativist acknowledges a role for justification, but does not see the appeal to authority as sufficient. Finally, a student in the final set of positions, categorized as "commitment to relativism," adopts a specific set of standards for justification and accepts responsibility for evaluating knowledge claims based upon those standards.

According to Perry, cognitive disequilibrium facilitates movement through these positions. Much like how it is described in the work of Piaget (1972), Perry believed that individuals have beliefs about knowledge, and that changes in these beliefs occur due to disequilibrating experiences. Thus, new experiences are either assimilated into the student's current epistemological position or force an accommodation of that stance. These accommodations can, over time, accumulate to such a degree that they force movement from one of Perry's positions to the next.

Work on Perry's model continues (see Knefelkamp's introduction to Perry, 1999 for a review), and includes the incorporation of more diverse samples, more formalized coding schemes for the interviews used to measure personal epistemology, and greater clarification of the relativist position as different than the kind of vulgar relativism eschewed by philosophers and psychologists alike (Gamache, 2002; Williams, 2002). Perry's model has also been criticized, in particular its upper positions, which seem to be less focused on issues of people's understanding of knowledge and more on emotional issues like commitment.

Perry's model has also proven difficult to measure (Hofer & Pintrich, 1997). Perry found that most college freshmen were dualists, with very few displaying advanced multiplicity or relativism by the end of the collegiate experience (Perry, 1999). It is curious that college students do not seem to make much progress through the model during what is commonly considered a time of tremendous maturation both cognitively and socially. The seeming failure of college students to develop to more advanced levels in the model has caused some to question the model's validity (Chandler et al., 2002). Nonetheless, the model has spawned a generation of researchers and a multitude of derivative models. Indeed, it has been said that much of the work done by researchers following Perry has been nothing more than a renaming or elaboration of his original positions (Chandler et al., 2002; Hofer & Pintrich, 1997).

King and Kitchener's Reflective Judgment Model

King and Kitchener (2004, 1994) began studying Perry's scheme in graduate school and from his work developed their model of Reflective Judgment. In their model, epistemic cognition concerns the limits, certainty, and criteria for knowing. For King and Kitchener, "epistemic cognition allows the monitoring of problem types and the evaluation of proposed solutions" (King & Kitchener, 2002, p. 38) including whether a solution even exists. In particular, King and Kitchener have focused on how late adolescents' and adults' epistemological assumptions influence their judgments regarding controversial, or ill-structured dilemmas such as whether news reporting is trustworthy and if nuclear power is a safe form of energy. These situations are ill-structured because they are designed to be intractable using logic alone, and necessitate that individuals use other means to determine the most reasonable decision or course of action. King and Kitchener (2004) say ill-structured problems are defined by two features: they can neither be defined nor solved with a high degree of certainty. Well-structured problems have clear answers that can be agreed upon by most if not at all people. Their work has been applauded for expanding upon Perry's upper positions (Hofer & Pintrich, 1997).

While there are in fact seven stages in the King and Kitchener model, there are three overarching levels that provide a sense of its structure (see Table 2).

Table 2

King & Kitchener's Model of Reflective Judgment

Stage	*View of Knowledge*	*Concept of Justification*
Prereflective Thinking	Absolutely certain, attainable through direct experience or appeal to authority	Not needed, disputes resolved by authority figures
Quasireflective Thinking	Uncertain, individual	Individualistic or context-specific
Reflective Thinking	Constructed, interpretations can be supported with evidence	Justification is defeasible and probabilistic, based upon evidence

The first level, prereflective thinking, is very similar to Perry's dualism. In the stages within this level, there is no differentiation of problems into well and ill-structured, instead, the knower assumes knowledge to be certain and that definitive answers exist for all questions. At first, justification for knowledge is seen as irrelevant, as people see an "absolute correspondence" (King & Kitchener, 2004, p. 6) between beliefs and reality. Development through this level is evidenced by an individual's acknowledgement that some beliefs are dependent upon personal opinion. However, people in this level continue to believe that eventually most opinions will be reconciled through an appeal to an authority that has direct access to an unchanging reality.

Movement into the second level of King and Kitchener's model, quasireflective thinking, comes with the recognition that knowledge is uncertain, and that definitive answers often do not exist. This is very similar to Perry's multiplicity position. People in this level see evidence for justification as either idiosyncratic or context-specific, with little to guide them in choosing to believe one knowledge claim versus another. Solutions to ill-structured problems are seen as completely dependent upon one's point of view. An important distinction between prereflective and quasireflective thinking is the source of justification moving from external authority figures to the individual's own construction.

In the reflective level, people recognize the contextual and constructed nature of knowledge. With ill-structured problems, justification for one's beliefs is created through an evaluation of different arguments, a determination of the weight of various kinds of evidence, and an assessment of the effectiveness of the solution. In addition, judgments are considered tentative, with reevaluation possible depending upon new experience or information. These people are able to articulate and use their standards of justification to evaluate knowledge claims while still acknowledging that all knowledge is probabilistic, not definite. Standards of justification can include testimony from authority, but only after that authority has been critically evaluated.

Like Perry, King and Kitchener's model is developmental, with reflective judgment as the endstate. In King and Kitchener's research, few individuals beyond doctoral students have approached this endstate (King & Kitchener, 2004). Movement through this model occurs as people interact with their surroundings, constructing their own understandings and meanings that spur change in their epistemological assumptions, through a process much like cognitive disequilibrium. With each level of the model, the complexity of thought increases. However, King and Kitchener do not endorse universality, or applicability of their model across cultures, a common claim of other developmental theories.

In addition, King and Kitchener purposefully choose to use the term stage, as opposed to Perry's term position, to describe the various aspects of their model. They argue for a specific interpretation of the word “stage” that allows for both a dominant stage response as well as responses from adjacent stages coming directly before or after the dominant in their developmental sequence. They present research (King, Kitchener, & Wood, 1994) that individuals have both a dominant stage-response as well as a tendency to respond to some ill-structured problems with a response characteristic of an adjacent stage. To best capture this, they advocate for an overlapping waves approach, with each stage’s wave representing the probability of a response indicative of that way of thinking. However, they do not believe this is evidence of domain-specificity, particularly given the fact that a high percentage of individuals’ responses to ill-structured problems can be characterized within one stage. Instead, they call this a complex stage model.

King and Kitchener’s model has mostly been tested using interview methodology. The Reflective Judgment Interview (RJI) consists of semi-structured questions about controversial problems such as the accuracy of news reporting. Using the RJI, they have found that increased age and educational attainment predict higher levels of reflective judgment (King & Kitchener, 2004). Two interesting findings are that people do not show differential levels of reflective judgment across types of dilemmas until reaching graduate school, and that in general social sciences doctoral students displayed higher levels of reflective judgment than doctoral students in the hard sciences (King & Kitchener, 2002). Undergraduates have been found to display uniform levels of reasoning across types of ill-structured problems, and this effect has been consistent across majors. However, there have been concerns that these studies have not had the statistical power necessary to find the relations they seek (Wood et al., 2002). In terms of their overlapping waves approach, King and Kitchener have found that the modal response for individuals changed as they expected, showing development over time and education. They had begun work on a quantitative instrument but, after much research, decided that they could not "produce an 'objectively scorable' [sic] version" of the RJI (Wood et al., 2002, p. 289).

Like Perry and others, King and Kitchener found that most college freshmen displayed epistemological thinking at the lowest levels, prereflective, with movement into quasireflective thinking by students' senior year. Overall effect sizes have been estimated to be almost one standard deviation from freshman to senior year (Pascarella & Terenzini, 2005). Criticisms of the model include the finding that only advanced doctoral students display the highest levels of epistemic cognition, and the researchers' focus on ill-structured problems in their measures, as opposed to including well-structured problems as well (Hofer & Pintrich, 1997). Finally, as with other personal epistemology models, there has been little research regarding the relations between reflective judgment and educational outcomes, such as classroom performance and study strategies (Pintrich, 2002).

Baxter Magolda's Epistemological Reflection Model

Another researcher in personal epistemology whose work derives directly from Perry is Baxter Magolda (2004). Initially seeking to develop a better measure for Perry's model, she became intrigued with differences in responses between men and women, although her later work has somewhat de-emphasized this gender focus (Baxter Magolda, 2001). Overall her Epistemological Reflection Model (EPM; Baxter Magolda, 1992, 2004) focuses on people's assumptions regarding the nature, limits, and certainty of knowledge. According to Baxter Magolda, by constructing meaning from their environmental context and experience, individuals form and continually reevaluate their epistemological assumptions. She views epistemological development as movement from simplistic to more complex assumptions regarding knowledge, facilitated by the interaction of those assumptions with experiences in the world. It is important to note that Baxter Magolda believes epistemological development is directly influenced by a person's context, thus some environments prompt movement through ways of knowing faster than others. Interestingly, she has recently said that she believes undergraduate education tends to stall students' development, leaving them stuck in what she calls a state of transitional knowing (Baxter Magolda, 2004).

Baxter Magolda has developed and refined her model over the course of a 20-year longitudinal study involving the same small group of students from a mid-Western liberal arts college. The model includes four "ways of knowing" that are very similar to Perry's positions in both content and developmental progression. These ways include absolute knowers who see knowledge as certain and authority figures as the arbiters of truth, followed by transitional knowers who begin to doubt authority and the certainty of knowledge in some contexts, such as the humanities (Baxter Magolda, 2004). Independent knowers see knowledge as uncertain and no longer trust authority, looking to themselves as the source of knowledge. This way of knowing is similar to Perry's multiplicity, in that the only means of justification seems to be "because I think it's right." Baxter Magolda found that few college students achieved this way of knowing, and those that did were seniors. Most participants in her longitudinal study entered independent knowing as a result of work experiences after college. Finally, very few participants ever became contextual knowers, or those who judge knowledge claims based upon their own context and rationality (Baxter Magolda, 2004). These participants found a balance between their own views and those of others, mirroring Perry's relativism and King and Kitchener's reflective stage.

Recently, Baxter Magolda (2004) has moved toward examining how individuals construct a personal epistemology that allows for self-authorship, or the ability to learn from disequilibrating experiences while maintaining a commitment to their own beliefs and sense of self (Baxter Magolda, 2001, 2003, 2004). For example, a person with a strong belief in evolution may benefit from discussions with a creationist, but only if that person is able to balance person commitment and sense of self with an openness to new ideas. She now views the various ways of knowing as steps toward positioning the self as the arbiter of right and wrong, while still allowing for the exploration of and learning from other's viewpoints. With this understanding comes a commitment to taking responsibility for one's beliefs and identity.

Baxter Magolda's longitudinal study of the same small group of students from one Mid-Western college is unique in its duration, now at almost 20 years, but has been criticized as being too focused on a single sample and lacking in methodological diversity (Hofer & Pintrich, 1997). Its key contributions are in exploring epistemological development beyond the college years, and recognizing the importance of balancing personal conviction with openness toward different perspectives.

Kuhn's Epistemological Thinking Model

Kuhn's (Kuhn & Weinstock, 2002) model revolves around the basic idea that epistemological maturity is a balance of objectivity and subjectivity. In the beginning, children see all knowledge as objective. Then, with development, all knowledge is seen as subjective. Finally, the endpoint of development is when knowledge is seen as a balance between subjectivity and objectivity. This progression is articulated in Kuhn's four-level model. Levels are differentiated on four variables: the nature of one's assertions, whether reality is knowable, the source and certainty of knowledge, and the role of critical thinking as means of establishing justification.

For example, children up to about age four are in the first level of Kuhn's model, realism, and see assertions as copies of a reality that is directly knowable, where knowledge is certain and derived from external sources, making critical thinking unnecessary (see Table 3). For realists, objectivity is the norm. Absolutists, children from about age 4 through adolescence, still believe that reality is directly knowable and that knowledge is certain and comes from external sources. However, because absolutists now see assertions as facts, rather than copies of an external reality, they see critical thinking as the manner by which disagreements between people can be resolved. Thus, to an absolutist, assertions are either correct facts or misinterpretations of reality, also called false beliefs.

Table 3

Kuhn's Model of Epistemological Thinking

Level	*Reality*	*Knowledge*	*Critical Thinking*	*Assertions*
Realist	Directly knowable	Certain, from external source	Unnecessary	Copies of an external reality
Absolutist	Directly knowable	Certain, from external source	Used to determine who is "correct"	Facts that can be correct or incorrect
Multiplist	Not directly knowable	Uncertain, from human minds	Irrelevant	Opinions that cannot be questioned
Evaluativist	Not directly knowable	Uncertain, from human minds	Used to make good decisions and facilitate understanding	Judgments that can be evaluated

For the multiplist, everything changes. The multiplist view, generally not seen until adolescence, contends that assertions are opinions about a reality that is not directly knowable. Knowledge, previously seen as something external to the knower, becomes subjective and therefore uncertain. Interestingly, like the realist, multiplists do not value critical thinking about arguments and positions, but in this case this is because they believe there are no "correct" answers to be discerned. Finally, the evaluativist sees reality and knowledge much in the way the multiplist does, but now recognizes that assertions are judgments based upon critical thinking. This level represents an integration of the subjective nature of knowing with the objectivity of critical thinking used to support one's judgments about that subjective reality. According to Kuhn (1999, Kuhn & Weinstock, 2002), few individuals actually reach an evaluativist epistemology, with many remaining in the multiplist level and some even becoming mired in absolutism for life. As Kuhn has said, the parallels between her model and others', including Perry, are clear (Kuhn & Weinstock, 2002).

One major difference between Kuhn's model and the ones previously reviewed is that Kuhn differentiates amongst different areas of knowledge. The scenarios she asks participants to judge vary from the very subjective, such as taste or aesthetics, to the seemingly more objective, phenomena she calls physical facts (Kuhn & Weinstock, 2002). The progression from an absolutist to multiplist viewpoint occurs earlier for the more subjective domains, such as aesthetics, and with time spreads to the more objective such as physical science. This developmental progression across domains is reversed in the move from the multiplist level to evaluativist, with the reintegration of objectivity occurring first with the more objective domains.

Kuhn has used both interview methods and a shorter, more objective instrument to measure epistemological thinking (Kuhn & Weinstock, 2002). Each measure presents participants with two viewpoints, and then asks whether only one viewpoint could be correct or whether both could be true to some degree. This question discriminates between absolutists and other more adaptive levels. Participants answering that both could be true to some degree are then asked whether one viewpoint has more merit, to discriminate between multiplists and evaluativists. The shorter measure includes 15 items of this sort. Kuhn and colleagues have not attempted to measure realist epistemological thinking.

Kuhn and colleagues have found that participants with more education are less likely to score as absolutists, and evaluativist thinking is more common in the domain of taste than it is in the domain of physical fact. Kuhn's hypothetical ordering of taste, aesthetics, values, social facts and physical facts from subjective to objective was supported by the data, but the values category did not develop in the predicted manner (Kuhn, Cheney, & Weinstock, 2000). Specifically, while the other domains developed in a relatively consistent order in the transition from multiplist to evaluativist, some participants remained multiplistic when it came to value judgments. Kuhn and colleagues (2000) suggest that values may be qualitatively different than the other domains. Nonetheless, across all groups and content areas, evaluativist thinking is not very common except among the graduate students.

Interestingly, Kuhn has found that participants younger than college age think predominantly in an absolutist manner in both subjective and objective domains. These findings have caused others to question whether Kuhn's measures are accurately capturing the epistemic cognition of young people (Chander et al., 2002). For example, it seems unlikely that teenagers would see all knowledge, including such subjective ideas as the legal drinking age, as certain and deriving from external sources.

In terms of their instruments, in Kuhn and colleagues' (2000) original study, their 15-item measure was not tested for reliability. Validity was examined by categorizing individuals using this measure and the longer epistemological interview, with a 73% agreement. In another study, a panel of seven PhDs in education, science education, and the history of education were given the measure, and each scored as evaluativists or multiplists in every domain, as expected (Tabak & Weinstock, 2005). Weinstock and colleagues (2006), using the instrument with a different sample, found a Cronbach's α of .71. Mason and Boscolo (2004) used this same instrument and found Cronbach's α for the five domains to range from .65 to .90, with three below .7. They did not examine construct validity. In all, this measure has shown some evidence of moderate reliability, but further study is needed to evaluate the validity of scores with different samples.

Kuhn's model differs from others in that it directly builds from research on developmental psychology (Carpendale & Chandler, 1996; Flavell et al., 1992) and in its domain-specificity. In addition, it addresses epistemological thinking from a very early age through adulthood. Other models of personal epistemology, such as those described previously, are more focused on young adults and older. Kuhn (1999) makes an important point, however, that children younger than four, who are realists, are not really even engaging in epistemological thought. To the realist, "assertions merely duplicate and reflect reality, they do not need to be evaluated" (Kuhn, 1999, p. 19) making the question of epistemological thinking at this age "moot" (Kuhn, 1999, p. 19). Therefore, I assert that any model of epistemic cognition, including the one formed and tested in this dissertation, need not address the thinking of very young children, as it is not epistemological in the way that the term is usually used.

Commonalities Among Personal Epistemology Models

These personal epistemology models do have much in common, including Perry as their inspiration (Chandler et al., 2002; Hofer & Pintrich, 1997). As reviewed previously, each of the models posits a general developmental sequence from a more naïve position regarding the nature and source of knowledge to a more mature one where positions and arguments are evaluated but the knower holds that any knowledge can be proven incorrect based upon the weight of future evidence. They all cover beliefs about knowledge's structure and how individual's beliefs about it progress from a dualistic, right or wrong perspective to a more contextualized one. The progression is developmental in that the positions come in a set sequence from less to more adaptive. Research into each of these models has found that students in college start in a very naïve epistemological state, and show little progress by the end of college. Given that college is often portrayed as a time of significant change, it is surprising that these authors have found little development in students' epistemic cognition. In addition, each of these models has either depended upon interview methods using trained raters (Baxter Magolda, 2002; King & Kitchener, 1994) or utilizes measures that have not been rigorously tested (Kuhn & Weinstock, 2002). As such, the models do not lend themselves to measuring the effects of interventions (Wood, Kitchener, & Jensen, 2002), and are subject to concerns regarding interview bias (Hofer & Pintrich, 1997).

Differences Between Personal Epistemology Models

While very similar overall, each of these models does have distinguishing characteristics. King and Kitchener's (2004) model has been applauded for elaborating upon the upper level of Perry's scheme and focusing upon justification. Baxter Magolda's (2004) model has emphasized the individual and his or her growing sense of self-authorship, or the ability to recognize the self as a legitimate arbiter of justification claims. In essence, Baxter Magolda's longitudinal research has given more depth to others' claims that relativism is a desired end-state for epistemic cognition. Kuhn and colleagues' (2000) model contributes to the personal epistemology literature by introducing the idea that an individual's beliefs about knowledge may vary depending upon the perceived subjectivity of the content area. In fact, Kuhn's model, with its acknowledgement of a domain-specificity, can be seen as the most similar to theory of mind work described later. Before leaving the educational psychology literature, however, multidimensional views of personal epistemology must be examined as an alternative to those previously outlined.

Multidimensional Views of Personal Epistemology

Schommer-Aikins's Epistemological Beliefs

In a radical departure from unidimensional personal epistemology models, Schommer-Aikins (Schommer, 1990) proposed that students' beliefs about knowledge could not be described using a developmental stage model. Instead, she posited that personal epistemology was a belief system comprised of five mostly independent dimensions that could vary asynchronously (Schommer-Aikins, 2004). Three of these dimensions were directly related to the nature of knowledge, a common theme in personal epistemology models. In addition, she questioned the scope of these models, suggesting that personal epistemology be broadened to include two dimensions concerning beliefs about the nature of learning. She based this assertion upon research done by both Dweck (Dweck & Leggett, 1988) and Schoenfeld (1983, 1985) whose work illustrated that beliefs about fixed intelligence and the speed of knowledge acquisition, respectively, were associated with student performance.

Therefore, Schommer-Aikins's model can be seen as comprised of two different categories of beliefs, those pertaining to the nature of knowing, and those pertaining to the nature of learning (see Table 4). The dimensions categorized under the nature of knowledge include the notions of certainty, structure, and source of knowledge, whereas the nature of learning dimensions include student beliefs about ability and how quickly learning should be expected to occur. Each of these dimensions was named according to its naïve pole.

Table 4

Schommer-Aikins's Model of Epistemological Beliefs

Nature of Knowledge Factors	*Nature of Learning Factors*
Certain knowledge	Quick learning
Simple knowledge	Innate ability
Omniscient authority	

The certain knowledge dimension represents beliefs about the stability of knowledge, with those at the naïve pole believing that facts do not change, while more sophisticated individuals believe that knowledge is constantly evolving. Beliefs about the structure of knowledge are represented by the simple knowledge dimension, ranging from a belief that knowledge is a collection of discrete facts to a view of knowledge as a set of integrated concepts. Students' beliefs about the justification of knowledge are captured with the omniscient authority dimension, ranging from dependence upon authority for "truth" to a reliance upon empirical evidence. As Schommer-Aikins has said (Schommer, 1990; Schommer-Aikins, 2004), these dimensions can be seen as deriving quite clearly from Perry's (1990) work. They are also similar to work on Cognitive Flexibility Theory (Feltovich, Spiro, & Coulson, 1997; Spiro, Feltovich, & Coulson, 1996) reviewed later.

The nature of learning dimensions, fixed ability and quick learning, are two of Schommer-Aikins's additions to the personal epistemology literature. The naïve pole of the fixed ability dimension represents the belief that intelligence is a trait that is set at birth, whereas those at the more adaptive pole see it as capable of being improved and changed. Finally, the quick learning dimension describes students' beliefs about the process of learning itself. Those with a naïve viewpoint believe that if they do not learn some piece of knowledge or procedure within a short period of time, they will not be able to learn it at all. Beliefs at the more adaptive end of the continuum allow for the possibility that learning can be gradual but achievable with effort.

As Schommer-Aikins's research into her model has progressed, the meanings and names of some of the dimensions have been altered slightly, but overall her model has not undergone any radical changes. Perhaps the most substantive theoretical addition suggested by Schommer-Aikins (2004) is that all personal epistemology research, including her own, needs to be embedded within research into other psychological systems. For example, in a recent article (Schommer-Aikins, 2004) she has advocated studying how her dimensions interact with beliefs about ways of knowing (Belenky, Clinchy, Goldberger, & Tarule, 1986) and self-regulated learning (Boekaerts, 1995). Most recent research into her model has focused upon examining how epistemological beliefs interact with other aspects of cognition and affect, such as ways of knowing (Schommer-Aikins & Easter, 2006), self-efficacy and self-regulation (Bråten & Stromso, 2005; Greene et al., 2006; Paulsen & Feldman, 2005), to influence academic performance.

Schommer-Aikins (2004) has stated that the contributions of her model to the larger personal epistemology literature include her model's incorporation of the nature of learning factors, the idea of independent dimensions of epistemological beliefs that develop asynchronously, and her development of one of the first quantitative measures of epistemological beliefs. Indeed, Schommer-Aikins's epistemological questionnaire (EQ; Schommer, 1990) has proven to be both a means by which Schommer-Aikins can test the validity of her model as well as a lightning rod for criticism of the model from others. The lack of construct validity evidence for the instruments designed to test her model

(Clarebout et al., 2001) has led to some questioning as to whether the underlying model is an accurate description of epistemological beliefs (Greene et al., 2006).

Research on Epistemological Beliefs

The theoretical argument for Schommer-Aikins's model has been made through articles in journals such as *Educational Psychologist* (Schommer-Aikins, 2004). The model has also been tested through an examination of the instrument designed to measure it, the EQ, or some close variant of it (Bendixen & Hartley, 2003; Bråten & Stromso, 2004; Conley, Pintrich, Vekiri, & Harrison, 2004; Elder, 2002; Kardash & Howell, 2000; Schommer, 1990, 1993; Sinatra & Kardash, 2004; Wood & Kardash, 2002). The rationale behind these studies is that if the model is an accurate representation of the dimensions comprising epistemological beliefs, then it should be possible to create an instrument to measure those latent constructs.

The epistemological questionnaire. Schommer-Aikins designed the EQ to measure each of the model's five dimensions. Examples of items from the EQ are provided in Table 5. Much of the research done on the EQ has investigated both its factorial and criterion validity. Unfortunately, exploratory and confirmatory factor analyses of the EQ, along with regression analyses to test its criterion validity, have produced mixed results (Hofer, 2005; Wood & Kardash, 2002).

Table 5

Examples of Items from Schommer-Aikins's Epistemological Questionnaire

1) Most words have one clear meaning.
2) When I study I look for specific facts.
3) I don't like movies that don't have an ending.
4) Scientists can ultimately get to the truth.
5) People who challenge authority are over-confident.
6) Self help books are not much help.
7) Successful students learn things quickly.
8) If a person tries too hard to understand a problem, they will most likely just end up being confused.
**Items from Schommer (1990) page 500.

In an initial study regarding the factor structure and concurrent validity of the EQ, Schommer (1990) combined individuals' scores on certain items into item parcels. Item parcels are created by calculating mean scores on subsets of items and using that score in the factor analysis, as opposed to the individual item scores. She hypothesized that certain parcels would load on common factors based upon her epistemological belief dimensions. Exploratory factor analysis (EFA) techniques showed limited support for four of the five factors. Three item parcels loaded on the innate ability factor, but one of these was not hypothesized to do so *a priori*. The same was true of the simple knowledge factor. In terms of the quick learning and certain knowledge factors, only one item parcel loaded on each. Two item parcels hypothesized to load on the quick learning factor did not, and one hypothesized parcel did not load onto the certain knowledge factor. The proposed omniscient authority factor was not supported by the EFA. While Schommer-Aikins interpreted these results as supportive of her model, others have questioned this conclusion (Clarebout et al., 2001).

In addition, two methodological decisions cast further doubt upon the results of this study. First, item parceling during scale construction and validation has been criticized as it may obscure issues of double-loading and measurement error (Bandalos & Finney, 2001; Wood & Kardash, 2002). In addition, because only select items were published, rather than the entire instrument, it was not clear whether the items in these item parcels had any face validity or sufficient content validity (Hofer & Pintrich, 1997). Second, because a confirmatory factor analysis (CFA) was not performed, the construct validity of the instrument is unclear (DeVellis, 2003). Overall, critics have suggested that it would have been preferable to perform factor analyses on the items themselves, rather than composites or subsets, and to use a separate confirmatory sample (Clarebout et al., 2001; DeVellis, 2003; Pett, Lackey, & Sullivan, 2003; Wood & Kardash, 2002).

Nonetheless, in the same study Schommer (1990) regressed measures of academic performance on factor scores in an attempt to establish criterion validity. Students high on the quick learning factor produced more simplistic conclusions in an essay task. In addition, students scoring high on the certain knowledge factor wrote their essays as if their conclusions were factual, as opposed to being more subjective. No effect size information was presented. These results suggest that high scores on these two factors are associated with academic behaviors that are most likely not beneficial in a collegiate environment.

A similar study (Schommer, Crouse, & Rhodes, 1992) attempted to replicate the factors found in the first examination of the EQ as well as use scores on the EQ to predict text comprehension, again among college students. In this study of the EQ, again using item parcels, three of the four epistemological belief factors from Schommer-Aikins's 1990 study were supported in the EFA: simple knowledge, quick learning, and certain knowledge. Item parcels did not load on the fourth factor as anticipated, so it was renamed from innate ability to externally controlled learning. Using accepted metrics at that time (Bollen, 1989), there was reasonable data-model fit for a CFA of these four factors; it is not clear, however, whether or not the CFA was performed on a sample separate from the one on which the initial exploratory work was done. If not, then it is possible that both the EFA and the CFA findings were the result of chance relations in the data (DeVellis, 2003).

In a second aspect of the 1992 study, aimed at providing evidence of the EQ's concurrent validity, Schommer and colleagues (1992) performed regression path analysis using scores on the EQ factors and found that the simple knowledge factor had both direct and indirect effects (mediated by test preparation) on exam performance, with a total effect of -.19 (Schommer et al., 1992). Unfortunately, the measures of test performance had low internal consistency reliability (Cronbach's α for the two measures were .66 and .56), calling into question these results.

Some research into the EQ's predictive and concurrent validity (Schommer, Calvert, Gariglietti, & Bajaj, 1997; Schommer-Aikins & Hutter, 2002) has used exploratory regression procedures such as forward selection. This practice has been criticized as being too dependent upon data rather than theory (e.g., Pedhazur, 1997). In essence, exploratory regression procedures are more likely to result in Type I errors due to capitalizing upon chance relations in the data. Looking beyond this concern, the 1997 study found that the only epistemological belief that predicted students' GPA was quick learning, with an R^2 of .06 for one cohort and .24 for another. In the 2002 study, only the simple knowledge and certain knowledge factors had a statistically significant relationship with participants' beliefs about a controversial issue, in this case whether men and women differ in their communication styles. The R^2 for these relationships were all below .1.

The EQ has also been tested with non-collegiate populations, such as high-school students (Schommer, 1993). Results showed support for the simple knowledge, certain knowledge and quick learning factors, but the item parcels hypothesized to load on the fourth factor did not do so. Consequently, this fourth factor was renamed from externally controlled learning to fixed ability. Using forward selection to regress GPA on factor scores, statistically significant results were found for all four subscales; unfortunately, the R^2 were all below .07, with two below .01. Such small effect sizes could be due in part to the low internal consistency reliability alpha estimates for the subscales with these participants, which ranged from .51 to .78.

While the aforementioned study examined the EQ and high-school students, another study tested the factor structure of the EQ with 1,200 middle-school students (Schommer-Aikins, Brookhart, Hutter, & Mau, 2000). For this study, the EQ was reduced to 30 items. While four factors were hypothesized, CFA results produced evidence for only three factors: certain knowledge, quick learning, and fixed ability. In addition, the correlation between quick learning and fixed learning was .96, suggesting a possible lack of discriminant validity between these latent constructs (Byrne, 1994). Again, the researchers regressed GPA on the three factors using forward selection, and found statistically significant results for fixed ability and quick learning. No effect size information was reported.

Other researchers have attempted to modify the EQ to improve upon its psychometric qualities. Jehng and colleagues (Jehng, Johnson, & Anderson, 1993) created their own items to measure the five dimensions in Schommer-Aikins's model, although they altered the simple knowledge dimension to be more reflective of beliefs about the orderly progression of knowledge. The authors assessed the content validity of the items by having them reviewed by educational psychology professors. Unfortunately, survey results with students revealed factor reliabilities of .42 to .59, even after the removal of ineffective items. Given that a measure cannot be valid without being reliable, these findings provide more evidence that there are legitimate concerns about the validity of scores from the EQ or measures derived from it.

In another study, Conley and colleagues (2004) adapted Elder's (2002) variation of the EQ for fifth grade students. They studied change in epistemological beliefs over time in a hands-on science classroom. Their CFA, utilizing the actual items and not item parcels, showed an adequate fit for a four-factor model including the source, certainty, development, and justification of knowledge constructs. However, there was a lack of discriminant validity between the source and certainty factors. On the two factors that did show good discriminant validity, development and justification of knowledge, students did not show any statistically significant pre- to post-test gains after controlling for initial achievement levels among students. Therefore, while this study is encouraging for its use of confirmatory methods, its results are somewhat limited in terms of their interpretability.

Wood and Kardash (2002) have attempted to establish the factorial validity of variants of the EQ by analyzing items rather than item parcels. They used principal axis factoring to analyze items from both the EQ as well as Jehng's version epistemological questionnaire (Jehng et al., 1993). Unfortunately, even when combining the best items from both measures, Wood and Kardash only managed to extract 22.05% of the variance, and only their Speed of Knowledge factor explained more than 4% of the variance in college students' GPA. This suggests that the underlying constructs were not measured well by their indicator items. In their work, Wood and Kardash (2002) suggested that other variables might be accounting for the relation between epistemological beliefs and student self-reported GPA such as general verbal ability or need for cognition (Cacioppo, Petty, Feinstein, & Jarvis, 1996).

Thus, the results of various exploratory and confirmatory factor analyses of the EQ, along with regression analyses to test its criterion validity, have been negative to mixed (Hofer, 2005; Wood & Kardash, 2002). The innate ability and simple knowledge factors have shown the most consistency in terms of *a priori* item parcel loadings and EFA results (Clarebout et al., 2001). However, the factorial validity of the EQ remains in question, as the other proposed factors have not been replicated across studies (Bråten & Stromso, 2005; Kardash & Sholes, 1996; Schommer, 1992, 1993; Wood & Kardash, 2002). In addition, it is unfortunate that many studies utilizing the EQ fail to perform any CFA to test whether the model holds for that particular sample (Hofer, 2000). While there have been some statistically significant relations found between certain factors and academic outcomes, the small effect sizes have called into question their practical utility. Therefore, the concurrent validity of the EQ has also not been established. The reliability of these measures of epistemological beliefs have either been low or not been reported, and numerous researchers have suggested that this needs to be addressed (Schommer-Aikins, 2004; Wood & Kardash, 2002). Indeed, in most studies with reliability information regarding the EQ, the factor scores have had Cronbach alphas below the common standard of .7 (Schommer, 1990, 1992; Schommer-Aikins, Duell, & Barker, 2002).

The epistemic belief inventory. Another group of researchers created the Epistemic Belief Inventory (EBI; Bendixen, Schraw, & Dunkle, 1998; Schraw, Bendixen, & Dunkle, 2002) in an attempt to address these issues concerning the reliability and validity of scores using the EQ. The EBI was designed to measure the five factors first outlined in Schommer's (1990) model of epistemological beliefs. The EBI combined some questions from the EQ with many newly created items. Analyses of the EBI's factorial validity used EFA techniques with the items, as opposed to parcels. Acceptable levels of reliability (test-retest correlations ranged from .62 to .81) and factorial validity for the theory's five factors (simple knowledge, certain knowledge, innate ability, quick learning, and omniscient authority) were found with undergraduate students. Unfortunately, CFA techniques were not used to cross-validate the EBI. Summed factor scores on the EBI did predict reading comprehension, but the R^2 were all below .04, providing weak support for concurrent validity. Other research on the EBI has found acceptable CFA fit, but the measure's reliability and variance extracted were both below common metrics (Greene et al., 2006). This implies that the measure is still not adequately capturing the constructs it purports to measure.

Summary of measures of epistemological beliefs. In general, measures of epistemological beliefs have been plagued by a number of concerns. First, much of the early research involved using item parcels in exploratory factor analysis to investigate factorial validity. This approach does not investigate whether the items that make up the parcels are indeed valid indicators of the construct or the parcel, and thus parceling items is not recommended when investigating an instrument's validity (Bandalos & Finney, 2001; Hofer, 2000). While later work utilized confirmatory factor analysis methods with the items themselves, there remain serious concerns about the stability of the factors across studies, the lack of common variance to be extracted in the measures, and reliability of these measures (Clarebout et al., 2001; Greene et al., 2006; Wood & Kardash, 2002).

In addition, predictive validity evidence has been weak, with most effect sizes small, or in some cases, nearly non-existent. It is perhaps not surprising that effect sizes for the predictive validity of epistemological beliefs have been small given the lack of reliability in the factors (Greene et al., 2006). Low reliability in dependent variables can cause a reduction in power. More concerning, however, is the fact that many studies utilize measures of epistemological beliefs as independent variables. Independent variables with low reliability not only decrease the power of the analyses, they can also bias the estimates of relations between the variables (Pedhazur, 1997). This may be why factor relations seem to vary between studies. While taking a structural equation modeling approach to the investigation of these relations would disattenuate the error in these measures, ultimately if the items are not adequate indicators of the constructs, no amount of statistical manipulation will ameliorate this problem (Greene et al., 2006). Finally, it is questionable as to whether criterion validity can be demonstrated utilizing GPA or exam performance as outcome variables, as is often attempted. These measures are almost assuredly influenced by numerous additional factors such as motivation, interest, and domain-specific means of testing. In particular, the domain-general approach adopted by Schommer-Aikins has been criticized as too large a grain size for adequate analysis.

Theoretical Criticisms of the Epistemological Beliefs Model

These criticisms of the EQ and associated instruments have often been accompanied by concerns about the underlying model as well (Hofer & Pintrich, 1997; Wood & Kardash, 2002). Authors have questioned the model's claims of domain-generality as well as its inclusion of the nature of learning dimensions, quick learning and fixed ability.

Domain generality versus domain specificity. Perry (1970, 1999) acknowledged that at any one time a student could be in different positions regarding different academic content areas, although he did maintain that there was a dominant position exerting influence over much of the student's interpretations. This belief in the domain-generality of personal epistemology is also found in the work of the more stage-like approaches (King & Kitchener, 2004; Baxter Magolda, 2004). While Schommer-Aikins's model of epistemological beliefs allows for independent development amongst the five dimensions, it does not allow for broad differences on those dimensions by domain.

To test this hypothesis, Schommer and Walker (1995) instructed college students to fill out the EQ twice, once while thinking about the items in terms of math and another time thinking in terms of the social sciences. They found that correlations between epistemological belief factors across domains were higher than cross-belief correlations, and used this as evidence of the domain independence of the model.

Schommer-Aikins and colleagues (2002) also claimed to have found evidence supporting the domain-generality of epistemological beliefs. In this study, they asked college students to fill out the EQ three times, each time thinking about either math, social science, and business. They found that epistemological beliefs between math and the social sciences were highly correlated, as were beliefs between math and business. They use this as evidence to support their claim that epistemological beliefs are "moderately domain general" (Schommer et al., 2002, p. 360).

However, other researchers (Buehl & Alexander, 2001, 2005; Buehl, Alexander, & Murphy, 2002; Hofer, 2000) have challenged the findings of both of the studies reviewed. Hofer (2000) points out that despite asking students to think about different domains, many of the items on the EQ, such as "I don't like movies that don't have an ending," are not related to academic domains at all. Buehl and colleagues (2001, 2002) concur, and note that academic domains have often been separated into discrete categories such as well-structured or ill-structured. The use of the term "structured" certainly suggests that academicians have differentiated domains along epistemological lines. In general, Donald (1990), by interviewing professors, provided evidence that the criteria used in establishing validation differ across academic domains. In the pure sciences, empirical evidence and the use of counterexamples were more often used to establish justification. In the humanities, peer review was more often cited as evidence for validation.

In terms of student beliefs, Stodolsky and colleagues (Stodolsky, Salk, & Glaessner, 1991) found that fifth graders saw social studies and math differently, believing the latter to be more objective, whereas the former was seen as less clearly defined. These student beliefs suggest different means of justification for each area. Torney-Purta (1994) argues that the complexity and thoroughness of the narrative is an important measure of justification in social studies and history because the problems are ill structured, with numerous potential solutions. She found that students often over-simplified complex forces and relations in political science and history into narratives about important historical figures and their presumed mental states. This led to students justifying beliefs as knowledge based upon those beliefs' congruence with these simplistic characterizations. This work aligns with that of Carretero and colleagues (1994), who argue that a mature understanding of historical processes requires attending to both the personal or narrative aspects of history as well as the political, economic, and social aspects. Clearly the standards by which knowledge can be claimed to be justified true belief differ by domain for both experts and students.

Domain-specificity has also been studied empirically. In a study based upon four of Schommer's (1990) dimensions (all but omniscient authority), Buehl and colleagues (2002) examined whether students' epistemological beliefs varied across the domains of math and history. After an extensive item design and analysis process, two factors were found through EFA and CFA cross-validation: need for effort and integration of information and problem solving. These two factors differed by domain, leading to a total of four factors in the analysis. This four-factor model did have good CFA fit according to Hu and Bentler's (1999) joint criteria. To test the hypothesis of domain-specificity, the authors compared the fit of this model to a model with only two domain-general factors. They found the four-factor model had a better fit and the chi-square difference test between the two models was statistically significant, indicating that the four-factor model was superior to the two-factor one. Further support for the domain-specificity hypothesis came in the form of a repeated measures MANOVA showing that participants' epistemological beliefs statistically significantly differed by domain.

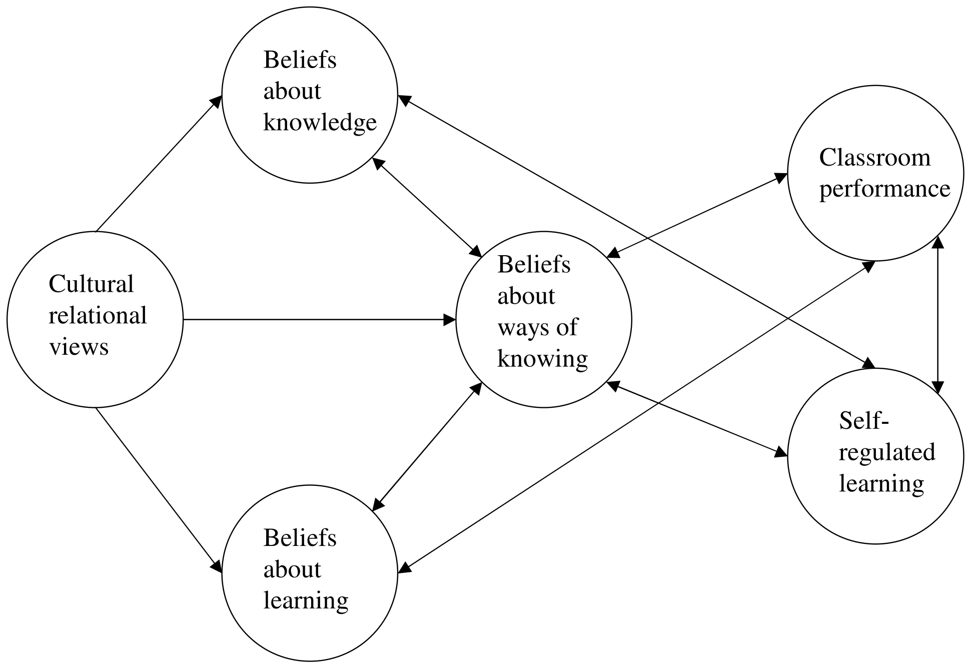
Of course, it may be that epistemological beliefs have both domain-specific and domain-general qualities. In another study, Buehl and Alexander (2005) used a variation of Hofer's (2000) instrument to assess whether students clustered into distinct groups based upon their epistemological beliefs. They also examined whether these clusters were different across the domains of history and math. They found that four distinct clusters of epistemological beliefs could be identified in each domain. The cluster profiles were not comparable across domains. However, when the authors categorized those clusters as either naïve or adaptive, they found a statistically significant correlation with a medium effect size. This suggests that while students' domain-specific epistemological beliefs can vary, there may be an overarching general level of sophistication that restricts this variance.

What is to be made of these conflicting findings? Schommer-Aikins has found evidence of domain-generality using her instrument. Yet others (Buehl et al., 2002; Buehl & Alexander, 2005; Hofer, 2000) have found evidence of domain-specificity using Schommer-Aikins's measure as well as instruments designed by the authors. Finally, more recent research has shown that epistemological beliefs may be distinct across domains, but have some domain-general similarities as well (Buehl & Alexander, 2005). It is difficult to make any firm statements regarding this issue given that the studies have been conducted with different instruments, measured different proposed latent factors, and varied in their analyses. Nonetheless, at this time it would seem unwise to state unequivocally that epistemological beliefs are domain-general. Based upon the epistemological beliefs literature alone, however, the degree of domain-specificity, and its nature, remains unclear.

Nature of learning dimensions. While Schommer-Aikins is not alone in positing a domain-general model of personal epistemology (Baxter Magolda, 2004; King & Kitchener, 2004; Kuhn & Weinstock, 2002), she is unique in suggesting that beliefs about intelligence and learning are part of personal epistemology (Schommer-Aikins, 2004). Schommer-Aikins calls these the nature of learning beliefs, and they include the dimensions quick learning and fixed ability. While some have questioned the factorial validity of measures of these beliefs (Clarebout et al., 2001), others have challenged the inclusion of these constructs based upon theoretical arguments (Hofer & Pintrich, 1997). Schommer-Aikins's (2004) response to this has been to both defend the inclusion of the nature of learning factors while at the same time de-emphasizing their connection to the nature of knowledge factors through her embedded systemic model of epistemological beliefs (see Figure 1). In this model, culture is shown as an influence upon both the nature of knowledge and nature of learning factors, but no direct connection exists between the two.

Figure 1

Schommer-Aikins's Embedded Systemic Model of Epistemological Beliefs



I believe Hofer and Pintrich are correct to question the nature of learning factors on theoretical grounds. Certainly the lack of evidence for factorial validity of the fixed ability dimension (Clarebout et al., 2001) provides little empirical support for its inclusion. In terms of the quick learning dimension, I question its epistemological status based upon a review of the philosophical literature on epistemology, described later.

Summary of Epistemological Beliefs Model

Schommer-Aikins's (2004) model has made significant contributions to the study of personal epistemology. The model was the first to suggest that there are multiple, independent epistemological beliefs. In addition, Schommer-Aikins developed one of the first quantitative measures of personal epistemology, and the number of studies that have used this instrument illustrates its influence upon the field. However, I do concur with the psychometric criticisms of the instruments that purport to measure epistemological beliefs. I also question Schommer-Aikins's nature of learning factors, and her claims of domain-generality. Each of these criticisms suggests that Schommer-Aikins's model may not be an adequate description of epistemological beliefs. These are all points first brought up by Hofer and Pintrich (1997), whose model I turn to next.

Hofer and Pintrich's Epistemological Theories

Hofer and Pintrich (1997) produced what many consider to be the definitive review of personal epistemology models. Both their 1997 article and subsequent 2002 book cover the major theories as well as methodological issues. One of the goals of these publications has been to attempt to provide some structure and direction for future research. Perhaps as a further means of establishing this structure, Hofer and Pintrich have developed their own model, called epistemological or epistemic theories (1997; Hofer, 2004b), that attempts to bring together the best of the models along with their own thinking regarding issues such as construct definition, model scope, development, and domain-specificity.

Construct Definition and Model Scope

Hofer and Pintrich (1997) point out that while definitions may vary, the constructs posited in most models of personal epistemology can be classified as either referring to the nature of knowledge or the nature of knowing. It is also important to note what is not included in Hofer and Pintrich's model. While it includes many aspects of personal epistemology theories, it does not include the nature of learning factors that Schommer-Aikins (2004) has claimed as a major contribution of her model. Hofer and Pintrich (1997) disagree with Schommer-Aikins:

> It is not clear if beliefs about learning, intelligence, and teaching should be considered as central components of epistemological beliefs…they do not explicitly deal with the nature of knowledge or knowing in terms of how knowledge is defined or justified…it seems to us that the domain of epistemological beliefs should be limited to individuals' beliefs about knowledge as well as reasoning and justification processes regarding knowledge. (p.116).

However, Hofer and Pintrich do seem to draw some inspiration from Schommer-Aikins's (Schommer, 1990) model. First, they propose a multidimensional model, as opposed to a monolithic one. Second, under their nature of knowledge category, they include two dimensions that utilize Schommer-Aikins's terms: simplicity of knowledge and certainty of knowledge. Simplicity of knowledge is conceptualized as a continuum ranging from the theory that knowledge is comprised of separate, understandable facts to a relativistic view of knowledge, dependent upon context. In terms of the certainty of knowledge dimension, this ranges from a faith in the absolute, unchanging nature of knowledge to the more advanced perspective that knowledge is dynamic and defeasible.

Under their nature of knowing category, Hofer and Pintrich include two dimensions: the source of knowing and the justification for knowing. For the source of knowing dimension, naïve individuals see knowledge as external, deriving from authority. As such they see themselves as incapable of generating knowledge. The more advanced position on this dimension involves seeing knowledge as a construction of the knower. Finally, the justification of knowing dimension concerns how individuals determine what beliefs qualify as knowledge. This dimension, it can be argued, is the least well-developed of the four, as Hofer and Pintrich (1997) do not elaborate upon it beyond a reprisal of Perry's general positions: "As individuals learn to evaluate evidence and to substantiate and justify their beliefs, they move through a continuum of dualistic beliefs to the multiplistic acceptance of opinions to reasoned justification for beliefs" (p. 120). Hofer (2004b) does expand this definition: "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" (p. 46). It is intriguing to note that in this definition, Hofer seems to recapitulate the general dualistic to relativistic progression of Perry (1999) while also conflating this explanation with aspects of her source and certainty of knowledge factors. I would argue that in each of the models of personal epistemology presented thus far, the justification of knowledge aspect has been least developed. This is ironic given that within philosophical epistemology, justification can be seen as the central question (see below; Pollock & Cruz, 1999; Williams, 2001).

Hofer (2004b) provides a further context for the model. Just as Schommer-Aikins (2004) has attempted to outline how her model of epistemological beliefs related to other constructs in educational psychology, Hofer attempts to position the model of epistemic theories. Specifically, she claims that the model is metacognitive, with the nature of knowledge dimensions influencing the acquisition and utilization of strategies, task definition, and beliefs about the self and context. For example, students with naïve views regarding the certainty and simplicity of knowledge may not choose to acquire advanced study strategies, believing that simple memorization is sufficient. She sees the nature of knowing dimensions as influencing metacognitive judgments and monitoring. In this case, beliefs about the source of knowledge may influence whether an individual questions a teacher, while justification beliefs would seem to provide a way for individuals to evaluate the claims of others.

Development

In terms of how these epistemic theories develop, Hofer (2004b) seems to embrace a process similar to other personal epistemology theories, suggesting that students move from more naïve positions to more advanced ones in a loose-stage manner. She differs from other personal epistemology researchers by acknowledging that epistemological development can begin prior to the college years. She argues that young children are sometimes forced to decide whom they believe when confronted with adults presenting discrepant views. However, she does not clearly state at what ages these stages might occur, or what developmental milestones might need to be passed before movement into the stage.

Domain-specificity

It is unclear whether Hofer and Pintrich's (1997) model is domain-general or domain-specific. They do review both alternatives, and then cite numerous works suggesting that domain-specificity might be conceptualized as being specific to general academic areas, such as math or history.

Hofer (2000) developed a measure called the Discipline-Focused Questionnaire (DFC) that was intended to measure the nature of knowledge and nature of knowing factors outlined in her previous work (Hofer & Pintrich, 1997). This measure was also designed to be adaptable to different domains, utilizing items such as "In this field, knowledge is certain." Undergraduates filled out one form with the items referring to psychology, and then another form with the items referring to science. Separate EFAs for the items on each form revealed a common four-factor solution for both of the domains.

The nature of knowledge dimensions were hypothesized to be orthogonal, but the results supported combining these two factors. The other factors were justification for knowing, source of knowledge, and attainability of truth. Cronbach α reliabilities for five of the eight factors (four per domain) were below .7. In terms of the research question regarding disciplinary differences in epistemological beliefs, Hofer found that there were statistically significant differences between each of the factor means for psychology and science. While the factors were correlated across disciplines, the correlations were moderate, ranging from .29 to .53. In addition, results from a repeated measures multivariate analysis of variance (MANOVA) showed that students' beliefs differed across domains for each factor. Hofer claims these results provide evidence supporting the domain-specificity of epistemological beliefs.

Hofer (2004b) also examined whether students' behaviors during online searching differed according to their degree of familiarity with the content. The implication would be that students with more experience in an area would have a higher level of domain-specific epistemic cognition. While she did find support for this hypothesis, only the most advanced students displayed this type of domain-specific difference in epistemic cognition. Many students majoring in the topic being searched did not utilize more advanced search strategies, suggesting they were not engaging in domain-specific epistemic cognition.

Summary

Hofer and Pintrich's (1997) work illustrates a number of things. First, their model demonstrates that many of the personal epistemology models can be combined without too great a loss of fidelity. Second, they provide a theoretical argument against classifying Schommer-Aikins's (2004) nature of learning dimensions as epistemological. Third, while it is as of yet not well-developed, Hofer's (2004b) statement that epistemic cognition most likely develops in secondary school or earlier is an important one. Theories that posit otherwise are subject to scrutiny, as Chandler and colleagues (2002) discuss. Hofer and Pintrich's inclusion of justification, as ill defined as it is, represents an important step toward acknowledging the philosophical literature on epistemology. Finally, Hofer (2004b) presents some evidence that personal epistemology may be domain-specific. However, I argue that there is more to be learned from the philosophical study of epistemology, and that each of the models reviewed could benefit from these lessons.

Philosophical Critiques of Psychological Studies of Epistemology

Hofer (2004a) has questioned whether psychologists' appropriation of terms from philosophy has led to some level of ambiguity and lack of precision. Others (Buehl & Alexander, 2001; Kitchener, 2002; Murphy, 2003) question whether psychological work regarding personal epistemology has strayed too far from the work of philosophical epistemologists in ways beyond nomenclature. A review of philosophical epistemology can help clarify meanings in psychology and shed light upon controversies in personal epistemology. After a general review of philosophical epistemology, I suggest that definitions in personal epistemology research should be clarified. In so doing, the controversy regarding Schommer-Aikins's (2004) nature of learning factors can be addressed. I believe an examination of philosophical epistemology can also illustrate why it is important to take a close look at other constructs in personal epistemology research, and separate those that are truly epistemological from those that deal more with ontology.

This will allow for a more internally consistent definition of personal epistemology and help resolve several key disputes in the field. I also demonstrate how an examination of philosophical skepticism can help illuminate concerns regarding domain-general views of personal epistemology.

Philosophical Epistemology

A description of philosophical epistemology is necessary to understand how it can inform the personal epistemology research in educational psychology. The study of epistemology itself is a philosophical inquiry into the proper means by which humans can justify knowledge qua knowledge (Pollock & Cruz, 1999; Williams, 2001). For example, one common problem in epistemology is how one can know that something is green, i.e. how can one be sure of "greenness" in the sense of knowing it? This seemingly simple question is actually quite complex, with many facets that have yet to be satisfactorily answered despite being studied at least since the days of Plato (Williams, 2001).

First, it is important to identify how epistemologists answer the question "What is knowledge?" (Williams, 2001, p. 1). This question has to do with the scope or limits of knowledge. Philosophers suggest that certain kinds of beliefs, due to their very nature, cannot be classified as knowledge. Williams lists opinion and faith as two examples. Pollock and Cruz (1999) claim that another area of interest to psychologists, morality, is not a fit subject for epistemological theory, as it is not clear that there are moral truths to be ascertained. One thing that is important to note here is that when philosophers ask the question "What is knowledge" they are not asking about its form, i.e. whether it is simple or complex, certain or changing, as some educational psychologists do. Rather, they are asking whether a differentiation can be made between knowledge and other kinds of beliefs.

The second relevant question is how philosophers actually go about differentiating knowledge from other kinds of beliefs. A simple view of the theory of knowledge would be based upon the question "How do you know?" but in actuality the question is more accurately stated as "What justifies you in believing?" (Pollock & Cruz, 1999, p. 12). In essence, epistemology deals with how one can be *justified* in claiming something as knowledge, as opposed to belief.

Until the early 1960s, most epistemologists agreed that for a belief to be elevated to the status of knowledge it had to meet three conditions: it had to be justified, true, and believed (see Pollock & Cruz, 1999 for a review). While the truth and belief conditions have sparked little controversy, there has been much debate regarding the justification condition. Philosophers' focus on justification as opposed to the other conditions comes from the fact that few would argue that knowledge qua knowledge must in fact be true and the person must actually believe it to be true to claim knowledge. The truth condition requires consistency in thought: "You know that all college professors are brilliant only if it is *true* that all college professors are brilliant. If there is one dull college professor, you do not *know* that all college professors are brilliant. Knowledge thus has a truth requirement" (Moser & vander Nat, 2003, p. 6). The belief condition works similarly, as it does not make sense to assert knowledge if one does not believe it to be the case. Thus, differences regarding satisfactory means of justification lie at the heart of most variants of philosophical epistemology (Murphy, Alexander, Greene, & Edwards, 2007), with concerns regarding this condition being voiced by Gettier (1963).

The justified true belief conditions for knowledge persisted until Gettier (1963) provided examples that illustrated that in some cases individuals can have a justified true belief, yet still fall short of having what a reasonable person would consider "knowledge." For example, John could be told by a reliable source that another person, Bob, is going to get be audited by the IRS. In addition, John may know that Bob lives down the street from him in Maryland. Therefore, John would be justified in this true belief: "The person who is going to be audited lives in Maryland." However, suppose that, in fact, John is being audited, not Bob. According to the justified true belief conditions, John's statement "The person who is going to be audited lives in Maryland" is knowledge because it does qualify as a justified true belief, but we would be hesitant to grant John's statement that honorific. John has what some would call "lucky" knowledge (Williams, 2001), and this demonstrates that the justified true belief conditions do not seem to be enough to properly define what we intuitively believe knowledge to be. Further conditions seem necessary.

The problem of lucky knowledge initially seemed to be a minor one, but has proven quite intractable (Pollock & Cruz, 1999; Williams, 2001). For every alteration to the justified true belief conditions that excludes an example like the one presented previously, a new example can be formed that defeats the alteration. In modern epistemology, one way theories differ is in how they attempt to bolster the justification condition to withstand Gettier's "lucky" knowledge. The debate continues as to which theories are most successful at excluding lucky knowledge (Pollock & Cruz, 1999). In addition, there are those who claim there is no solution to the problems with the justification condition, a stance called skepticism.

This discussion of the general form of philosophical epistemology outlines some key points. First, it highlights that philosophical epistemology focuses upon what beliefs can be claimed to be knowledge, and not whether that knowledge is simple or certain, as many educational psychologists do. As others have stated (Murphy, 2003), by more closely following these definitions and ideas within philosophical epistemology, it may be possible to resolve some of the construct definition problems in found in personal epistemology research. This will prove important later in terms of identifying relevant constructs in my model of epistemic and ontologic cognition. Second, it illustrates the importance of justification in epistemology. Finally, it introduces the idea of skepticism, and its relation to justification. An understanding of skepticism and its refutation will also prove useful in examining the domain-generality versus specificity controversy in personal epistemology research.

Definitions in Personal Epistemology

The definitions and terms used in personal epistemology can cause confusion. Authors tend to use slightly different terms to describe similar constructs, such as epistemological beliefs (Schommer-Aikins, 2004) and epistemological theories (Hofer & Pintrich, 1997). However, there are also more serious concerns regarding construct definitions. The actual term "epistemological" carries with it a specific interpretation that does not seem to align with its use in the field of educational psychology. In addition, even within educational psychology, there are disagreements about what constitutes "epistemological" beliefs or factors. I believe that utilizing definitions more in line with those from philosophy suggests that the nature of learning factors are not epistemological. Finally, I assert that many of the constructs in personal epistemology are in fact ontological in nature. Each of these issues will be described next.

Theories of Knowledge

Kitchener (2002) believes the term personal epistemology is a misnomer. First and foremost, if epistemology is a "theory of knowledge" (Kitchener, 2002, p. 92) then the term personal epistemology implies that each individual has an articulated theory regarding what is and is not knowledge. The term "epistemological beliefs" implies that people have beliefs about the *theory of knowledge*. To argue that adults and children have a theory of knowledge is to argue that all people are philosophers, and a review of philosophical epistemology reveals that thinking in this area is not typical of the average adult or child. Kitchener is not at all convinced that adults, let alone children, have specific beliefs or theories regarding knowledge. Instead, Kitchener argues that people engage in epistemic cognition, or thoughts about knowledge. I agree with Kitchener (2002) that the terms "personal epistemology" and "epistemological beliefs" are misnomers. Therefore, in my model I will use the term epistemic cognition to illustrate that its focus is upon thinking about knowledge, and that this thinking may or may not occur at a conscious level.

Nature of Learning

Hofer and Pintrich (Hofer & Pintrich, 1997; Pintrich, 2002) have questioned whether certain dimensions proposed by educational psychology researchers are actually "epistemological." In particular, they have questioned Schommer-Aikin's (2004) nature of learning dimensions. As I have shown in the discussion of the general form of epistemology, the philosophical literature (Pollock & Cruz, 1999; Williams, 2001) has little to say about learning and its nature. Therefore, I assert that whatever Schommer-Aikins's (2004) factors of innate ability and quick learning are measuring, they are not "epistemological" and as such should not be included in the study of personal epistemology. This does not mean that they are not important, but rather that they are mis-categorized, and researchers' continued attempts to force the nature of learning constructs under the umbrella of epistemology is hampering an understanding of both. I would argue that the nature of learning factors are related to epistemology in the same way that other educational psychology constructs such as self-efficacy are related: as covariates with which epistemological beliefs are to be studied.

Epistemology versus Ontology

Just as there is limited discussion of learning in the philosophical epistemology literature, there is also little discussion of the nature of knowledge as described by Hofer and Pintrich (1997). Hofer and Pintrich describe two aspects of the nature of knowledge: certainty and simplicity. The certainty of knowledge deals with "the degree to which one sees knowledge as fixed or more fluid" (Hofer & Pintrich, 1997, p. 119-120). Simplicity refers to a continuum where "the lower-level view of knowledge is as discrete, concrete, knowable facts; at higher levels individuals see knowledge as relative, contingent, and contextual" (Hofer & Pintrich, 1998, p. 120). Yet, as discussed previously, philosophical epistemology is concerned with how one goes about justifying knowledge qua knowledge, and not with the characteristics of that knowledge (Pollock & Cruz, 1999; Williams, 2001). What I think personal epistemology researchers want to capture with these nature of knowledge constructs is the idea that people come to recognize that *academic domains* are complex, and that our understanding of them changes over time. These ideas are not epistemological, however. If anything, this understanding is more about the ontology of those domains, i.e. about the features of the domain and the relations between those features (Pollock & Cruz, 1999). The philosophical area of metaphysics includes both epistemology, the study of how one can justify a claim as knowledge, as well as ontology, or the categories of existence and their relations. When psychologists question whether young children recognize that knowledge in history is an ill-structured domain, or a complex web of assertions and viewpoints with no objectively "correct" answer, they are questioning children's ability ontologic understanding. These are questions about the nature of those domains themselves, not how beliefs about those domains are justified. A complete review of ontology is well beyond the scope of this dissertation, but it is important to understand how ontology and epistemology differ.

While they use the term "epistemological" rather than ontological, I believe the work of Feltovich and colleagues (Feltovich et al., 1997; Spiro et al., 1996) on cognitive flexibility theory illustrates how the nature of knowledge factors should be conceptualized. Cognitive flexibility theory says that there are certain kinds of world-views. The first kind is called a reductive world-view. People with this type of world-view are characterized as utilizing single representations for complex systems, decomposing those systems into presumably additive parts, and having intolerance for ambiguity. These beliefs predispose learners to oversimplification. The second type of world-view is expansive and flexible, including multiple partial representations of knowledge, an appreciation of interconnectedness, and a tolerance for ambiguity. While these world-views sound like the poles of the nature of knowledge continua, an important difference has to do with the "grain-size" (Spiro et al., 1996, p. S59) of the constructs.

In cognitive flexibility theory, the world-views are limited to ill-structured, complex aspects of domains. As Spiro and colleagues (1996) point out, at a smaller grain size such as when the novice learner attempts to grasp the fundamentals of a new area of knowledge, the reductive world-view can actually be quite adaptive. As novice learners gain more expertise in an area, they come to understand that the relations between these fundamentals are complex and dynamic, necessitating a move to an expansive world-view. Thus cognitive flexibility theory focuses on beliefs about relations within the domains of knowledge themselves, not the means by which they are justified. Similarly, I believe that when personal epistemology researchers discuss the nature of knowledge, they are actually interested in the way students conceptualize relations amongst various aspects of academic domains, not in how students justify their beliefs. Conceptualized this way, the nature of knowledge claims describe how beliefs about *domains* influence learning. Personal epistemology's nature of knowledge dimensions are not epistemological because they do not concern how students justify their knowledge. Rather, these beliefs are ontological, concerning how students perceive the relations between aspects of academic domains, as either simple or complex, certain or dynamic.

Thus the dimensions regarding the nature of knowledge, while not epistemological, do play an important role. In fact, it would seem that for a person to believe that justification is truly necessary, the person must think that knowledge of reality is a more complicated matter than simply what one perceives. For people who view the world as simple and certain, what would be the purpose of justification? For those with a naïve view of ontology, differentiating between kinds of justification is unnecessary because the world is indeed simple, unchanging, and readily accessible. Justification is merely a matter of confirming a claim with reality. On the other hand, mature learners crave justification specifically because they believe that the world is not a simple place, and that it has a complexity and dynamism that overwhelms their powers of perception. As I describe in my model, I believe these ontological nature of knowledge dimensions discriminate between those that hold the naïve view that any means of justification is sufficient from those with a more adaptive view, that not all means of justification are created equal. Similar to Vosniadou's (2007) views regarding ontological commitments and King and Kitchener's (2004) model's claims regarding the need for justification, I assert that without ontological sophistication, epistemological sophistication is not possible.

Justification and Skepticism

As mentioned previously, skepticism has been a persistent problem in epistemology, and some would say it has been the dominant problem (Williams, 2001). The focus upon justification in philosophical epistemology naturally leads to the question as to whether said justification is even possible. Those that say it is not are called skeptics, and their arguments, as well as the counterarguments against them, will prove useful in terms of better understanding the domain-generality versus specificity debate in personal epistemology.

While there are numerous variants of the skepticism problem, most follow one of two lines of reasoning. First, a skeptic might say that any justification for knowledge must be built upon other pieces of knowledge, which in turn require their own justification, leading to an infinite regress. For example, I might claim that the earth is round, and use a science textbook as my justification. However, the skeptic would ask how I am justified in claiming that that textbook contains knowledge. I might counter that the scientists cited did good research, and the skeptic would similarly ask how I know that to be true, et cetera. It is easy to see how this line of questioning might go on forever, with the skeptic consistently calling into question whatever evidence I bring forth. To circumvent this, some philosophers claim that certain kinds of knowledge require no justification, i.e. some kinds of knowledge are foundational (Williams, 2001). For example, some philosophers grant perceptions such status (Pollock & Cruz, 1999). The skeptic would then alight to his or her second line of reasoning, asking how I can know that my senses are accurate. The skeptic might ask how I can be sure that I am not just a "brain in a vat" (Pollock & Cruz, 1999) akin to Keanu Reeves in the movie The Matrix. Since my only ways of interacting with my world are through my senses, ultimately the skeptic would say I have no means of justifying that I should trust my senses. This line of argument seems quite similar to the vulgar relativism of the multiplist, who argues that no one can "prove" that their beliefs are any more true than someone else's (Perry, 1970, 1999).

These lines of argument seem compelling and have challenged philosophers for hundreds of years (Pollock & Cruz, 1999). However, modern epistemology refutes them in ways that shed light not only on philosophical thought, but also psychological thought regarding epistemology. The first argument against skepticism is theoretical. The skeptic not only questions our beliefs, but also our means of evaluating them. In so doing, the skeptic leaves us nothing with which to contradict his or her argument. To have a discussion, the skeptic must grant us either our beliefs or the means by which we evaluate them; otherwise there is no starting.

The second argument against the skeptic concerns the supposedly inevitable conclusion that follows from his or her premises: that knowledge is impossible. How can this be, when we have a sense of which beliefs seem more likely than others? This unexplained but palpable sense of certainty regarding knowledge in and of itself provides some reason to reject any argument that claims we cannot have knowledge qua knowledge. To bolster this position, we must remember that when faced with an argument whose premises lead to a counterintuitive conclusion, we do not have to accept it. Rather, we can reject the conclusion and assume one of the premises is false. Skepticism is such an argument. It is, in fact, a *reductio ad absurdum* argument (Pollock & Cruz, 1999), meaning the conclusion seems less likely than the possibility that one of the premises is false. When this is the case, we reject the argument. Skeptical arguments do not undermine epistemology; rather they are useful foils for pointing out what epistemology is as of yet not able to adequately explain. Any epistemology theory that can be felled by a skeptical argument is a theory that needs further alteration, but it does not follow that a successful skeptical argument against one or all epistemological theories necessarily substantiates skepticism as a true description of knowledge, or the lack thereof. Ultimately, "the task of the epistemologist is not to show *that* the skeptic is wrong but to explain *why* he is wrong" (Pollock & Cruz, 1999, p. 10).

These theoretical arguments against skepticism can also be bolstered by a more practical argument. While skepticism may seem compelling in theory, no one lives his or her life as a true skeptic (Williams, 2001). True skeptics would doubt their ability to "know" anything about the world, even their own existence or the existence of their peers. True skeptics would have little need for laws or banks or even interaction itself. Being unconvinced that one could be "sure" of anything, the true skeptic would have no reason to engage in any activity for fear that at any moment, something wild and absurd might happen, with no discernable cause or consequence. As Williams (2001) points out, knowledge is valuable, and necessary for humans to live their lives, and even the most fervent skeptic acts in ways that suggest he or she has knowledge.

Skepticism and Domain-Generality

Thus, the philosophical argument for skepticism is not plausible either theoretically or practically. But, of what use is this discussion for psychological views of epistemology? I would argue domain-general unidimensional personal epistemology theories imply people are true skeptics. Hofer and Pintrich's (1997) definitive review article on personal epistemology states that an individual in Perry's multiplicity "is inclined to believe that all views are equally valid and that each person has a right to his or her own opinion" (p. 91). In their own conceptualization of epistemological theories they claim: "As individuals learn to evaluate evidence and to substantiate and justify their beliefs, they move through a continuum of dualistic beliefs to the multiplistic acceptance of opinions" (Hofer & Pintrich, 1997, p. 120). Kuhn's multiplists develop such an appreciation for subjectivity that

> "it overpowers and obliterates any objective standard that could serve as a basis for comparison or evaluation of conflicting claims. Because claims are subjective opinions freely chosen by their holders and everyone has a right to their opinion, all opinions are equally right." (Kuhn et al., 2000, p. 310).

King and Kitchener (2004) describe their quasireflective thinker using this quote from a student, "People think differently and so they attaack (sic) the problem differently. Other theories could be as true as my own, but based on different evidence" (p. 42). Baxter Magolda (2002) provides an example of one of her students saying "Everything's relative; there's no truth in the world. Each individual has their own truth" (p. 95). In each of these models, there is a position where students are posited to doubt that sufficient justification is possible. A domain-general view of personal epistemology, coupled with a belief in a multiplistic stage of knowing, is equivalent to philosophical skepticism. As stated earlier, philosophical skepticism is not a practical position, and as such is unlikely to accurately describe people's personal epistemology.

One could argue that personal epistemology researchers do not advocate for true skepticism, but rather only skepticism when it comes to the area of academics. However, this qualification has not been stated. In addition, it is not clear why or how individuals would choose to separate their academic views of knowledge from all others. Why would a student choose a skeptical view towards English, history, and physics and not have that view infiltrate the rest of his or her beliefs about the world? Indeed, could such a compartmentalization even be possible? I argue that it is not.

What does this mean in terms of my model? I believe both the theoretical and practical arguments against skepticism suggest that domain generality in epistemic cognition is highly improbable. I claim that the domain-general view, as well as the more restricted academics-only view, is flawed. Any model of epistemic cognition must describe not only the path of epistemic development, but also describe how that path differs dependent upon domain. What remains at issue is the nature of this domain-specificity, an issue I address later.

Summary of Philosophical Critiques of Personal Epistemology

Thus, the philosophical literature on epistemology helps clarify conceptual problems in the psychological literature. Specifically, by more strictly adhering to the definitions within philosophical epistemology, the controversies regarding the nature of learning and nature of knowledge dimensions can be resolved. Ironically, none of these dimensions are truly epistemological. The many problems outlined previously regarding the measurement of personal epistemology (Clarebout et al., 2001; Greene et al., 2006; Wood & Kardash, 2002; Wood, Kitchener, & Jensen, 2002) may be due to misconceptions regarding the nature of learning and knowledge constructs. Justification is at the heart of epistemology, and must be emphasized to a greater extent in the personal epistemology literature. Philosophical epistemology's denunciation of skepticism provides a means of arguing against domain-general views of personal epistemology. However, there still remain concerns regarding personal epistemology literature that the philosophical approaches discussed cannot address. Chief among these concerns is the reconciliation of personal epistemology theory and research with that of the developmental psychology literature, particularly within the research area called the theory of mind.

Developmental Psychology and Personal Epistemology

Within developmental psychology there exists a line of research called "theory of mind." Psychologists who work in the area of theory of mind study how children come to an understanding of their own mental states, as well as those of others. These researchers investigate how children develop an understanding of concepts such as metacognition, false belief and subjectivity (Flavell, 2004).

Some theory of mind researchers have questioned personal epistemology research. These psychologists suggest that personal epistemology researchers' focus on college students and adults has been myopic, and that theory of mind research with children can clarify some of Perry and others' counterintuitive findings. For example, Chandler and colleagues (2002) argue that it seems unlikely that students entering college could be dualists and yet still display the kinds of cognitive skills necessary to be admitted to higher education. In addition, the idea that traditional age college students have an unflinching faith in authority would seem doubtful to parents who have tried to explain to their teenager why he or she cannot do whatever he or she pleases. Finally, the idea that college students are dualists who only see the world in terms of right and wrong begs the question of how younger teenagers and children view the world. Either a young child's epistemic cognition is not too far removed from that of a college student, or there must be more to epistemic cognition than personal epistemology researchers have described. The latter is the more plausible option.

I believe theory of mind research can inform personal epistemology models regarding the epistemic cognition of both younger children as well as college students. In addition, this area of research provides further support for the resolution of domain-generality and specificity advocated by Buehl and colleagues (Buehl & Alexander, 2005; Buehl et al., 2002). While a complete review of the literature is again well beyond the scope of this dissertation (see Chandler & Carpendale, 1998 for such a review), there are key points that are important to clarify here before moving on to how this research informs personal epistemology.

Theory of Mind Studies

Personal epistemology literature has focused, for the most part, on high-school students and older (King & Kitchener, 2004; Kuhn & Weinstock, 2002, Hofer & Pintrich, 1997; Perry, 1970, 1999; Schommer-Aikins, 2004). However, as Chandler, Hallet and colleagues point out (Chandler et al., 2002; Hallett, Chandler, & Krettenauer, 2002), issues of epistemological understanding do exist for young children, and have been studied in the theory of mind literature. Researchers of the theory of mind seek to understand how children make the transition from a very naïve view of knowledge to a more nuanced one. This naïve view includes beliefs such as

> minds are only obliged to "fit" the world, that only exogenous factors shape mental life, that people can only passively accommodate to the pressures of outside experiences, and that they always copy but never construct the reality with which they interact. (Chandler & Lalonde, 1996).

Researchers have termed this view a "copy theory" of knowledge (Chandler & Boyes, 1982). Flavell and colleagues (1992) demonstrated that this belief in a directly knowable reality extends beyond physical facts to include morality and social conventions as well. Very young children not only believe that there are answers to all the world's questions, but that those answers are known to all.

Around the age of 4 or 5, children move into a realization that individuals can be deceived, or have a "false belief" (Carpendale & Chandler, 1996; Lalonde & Chandler, 2002; Perner & Davies, 1991; Wellman, 1990). Around age 7, children begin to recognize that two people can be equally well-informed about reality, but still legitimately disagree in terms of their interpretation of it. Particularly in the area of aesthetics, children at this age understand that people can interpret the same stimulus differently. They recognize that not all people like the same kinds of foods or the same kinds of music. Chandler and Lalonde (1996) have argued that this "interpretative" theory of mind comes necessarily after an understanding of false belief, and represents another qualitative shift in a child's epistemic cognition. This interpretative theory of mind, with its subjectivity in terms of aesthetics only, is different than a view that allows for subjectivity in areas beyond aesthetics.

The move into a more constructivist, or relativist, state of epistemic understanding requires cognitive abilities not present until the time of Piaget's stage of formal operations (Chandler, Boyes, & Ball, 1990). Research has shown that children who have achieved formal operations can think in a relativistic way about familiar issues, such as at what age it is appropriate to let people drive (Boyes & Chandler, 1982; Chandler, Boyes, & Ball, 1990). This kind of thinking extends beyond aesthetics, into academic areas, although not all individuals are expected to display constructivist thinking in every area of knowledge. Thus, this ability to understand that people can have access to the same reality while also having different but legitimate interpretations of it is called a constructivist theory of mind (Lalonde & Chandler, 2002) and represents another qualitative change in a child's thinking.

Theory of Mind and Personal Epistemology

So how does the theory of mind literature inform work in personal epistemology? First, it illustrates that the rudimentary understandings of false, but justified, belief occur at a very young age. Then, around the time of concrete operations, young children can be expected to understand that some kinds of knowledge, such as aesthetics, are subjective, or based upon one's interpretation. It is difficult to reconcile these findings with personal epistemology models that claim that college students are dualists, expecting the world to be composed of right and wrong answers (Chandler et al., 2002). In addition, theory of mind research illustrates that the cognitive processes necessary for constructivist thinking in academic areas are developed by the time of formal operations, far before personal epistemology researchers claim they manifest.

Thus, the theory of mind literature, by focusing on epistemological development in young children, has unearthed a compelling question: If children develop a sense of false belief at 4, interpretation at age 7, and the cognitive skills to think constructively at age 11 or 12, why do personal epistemology researchers (King & Kitchener, 2004; Perry, 1990) find no movement from dualist viewpoints until well into the college years (18-20; Hallet et al., 2002)? If it is possible that the move from dualism to multiplicity can occur as early as middle school, why are personal epistemology researchers missing it?

Chandler's Integration of Theory of Mind and Personal Epistemology Models

Chandler and colleagues (2002; Hallet et al., 2002) claim that the somewhat counterintuitive findings of Perry (1990), King and Kitchener (2004), and Schommer (1992) regarding the rather late development of constructivism, or more advanced epistemological beliefs, in students of college age is a direct result of the failure to recognize that epistemic understanding is not domain-general, but instead varies dependent upon the nature of the domain. While Chandler and colleagues use slightly different terms, in essence they claim that epistemic cognition can differ depending upon whether the domain of interest is ill or well-structured. A proper model of epistemic cognition, they suggest, should take into account this level of domain-specificity, and be able to describe epistemic development from preschoolers to adults.

Chandler and his colleagues have incorporated research from the theory of mind literature and personal epistemology to create a model of epistemic cognitive development that can account for the diverse findings of the two literatures (Chandler et al., 2002; Hallet et al., 2002). They propose a developmental model that posits that epistemic cognition moves through a stage-like progression, but that this development is not domain-general. This stage-like progression occurs independently within three related but separate types of knowledge. Thus, a person may be in one stage for a given type of knowledge, but in a different stage for another. The basic stage-like progression will be described first, and then the different kinds of knowledge.

This progression has four stages including five positions: realism, defended realism, dogmatism, skepticism, and rationality (Chandler et al., 2002; Hallet et al., 2002). Naïve realists believe that knowledge is directly derived from experience, and that any disagreements between people are due to those people having access to different facts. Naïve realists expect that if all people were exposed to the same information, there would be no disagreements and "truth" would be "known" to all. Thus, these children are able to understand false belief, but do not yet have an interpretative theory of mind (Lalonde & Chandler, 2002). Defended realism is not possible until the development of concrete operations, and is evidenced by the child's acceptance that some kinds of knowledge, mostly aesthetics, are based solely upon opinion, but that everything else is as the realist believes. This is the beginning of the development of an interpretative theory of mind. However, it is interesting to note that later work by Chandler and colleagues (Hallet & Chandler, 2002) omits this defended realism stage.

The next stage, only possible with the development of formal operations, is a reaction to the growing sense that knowledge, beyond aesthetics, may be entirely subjective, or constructed. Chandler and colleagues (2002; Hallet et al., 2002) believe people respond to this by either becoming dogmatic and seeking truth only in some authority figure(s) or by becoming skeptics, arguing that knowledge or truth is not possible. Both views share the idea that because knowledge is a human construction, rationality cannot be trusted as a means of justifying knowledge. Finally, people in the last stage, rationality, are able to outline methods and standards for judging the adequacy of knowledge-claims, and establish that some are more justified than others (see Table 6). That the final stage of development is called rationality aligns nicely with the philosophical literature, as some philosophers believe epistemology is the study of rationality and how it can be determined (Pollock & Cruz, 1999).

Table 6

Chandler's model of epistemic development (Hallet et al., 2002)

	Stage 1	*Stage 2*	*Stage 3*		*Stage 4*
	Realism	Defended Realism	Dogmatism	Skepticism	Rationality
Description	"Knowledge" is factual, disagreements due to people having different experiences	Aesthetics and taste are subjective, but all other kinds of knowledge are factual or objective.	Human rationality cannot be trusted, must depend upon some authority for "knowledge"	"Knowledge" is not possible in any sense, one cannot trust human rationality	Acknowledge-ment that humans construct knowledge but belief that "knowledge" claims can be evaluated and weighed as more/less likely based upon rationality and/or other means
Minimum Level of Piagetian Cognitive Development Necessary for this Stage	Preoperational	Concrete Operations	Formal Operations	Formal Operations	Formal Operations

Epistemic Development Within Areas of Knowledge

This stage-like progression is not domain-general, however. Chandler and colleagues (2002) argue that people separate facts into different categories, and may hold different positions in each of these categories. Unlike some personal epistemology models that posit a domain-general form of epistemic cognition, and models that suggest domain-specific epistemic cognition for every academic field of study, Chandler and colleagues claim that epistemic cognition varies by "domains of understanding" (Hallet et al., 2002, p. 290). These domains include aesthetics, and two other areas that are roughly equivalent to the distinctions used by Buehl and colleagues (2001, 2002): ill-structured and well-structured.

They believe children's beliefs about aesthetics are the first to move from a naïve realist viewpoint, around age seven. It is at this age that children adopt an "interpretative" view of knowledge, understanding that at least in the area of aesthetics, individuals can legitimately disagree, and there is little in aesthetics that can be called "knowledge." Around age 12, children's beliefs regarding ill-structured academic domains, such as history, begin moving from the realist stage into either dogmatism or skepticism. Finally, beliefs about well-structured domains, such as the physical sciences, are the last kinds of knowledge subject to this progression, occurring sometime late in adolescence or early adulthood.

Chandler and colleagues believe that by categorizing individual's epistemic cognition within these three types of knowledge, their model can account for the divergent results found by theory of mind and personal epistemology researchers. Theory of mind researchers have found that young children display an understanding of subjectivity when it comes to taste. For example, children understand that a cat may like the taste of catfood, whereas a person would not (Flavell, Flavell, Green, & Moses, 1992). Adolescents and college students can display relativistic thinking when it comes to what should be an appropriate age to begin driving, an ill-structured idea, but still think in a realist way about well-structured areas such as science. Chandler and colleagues (2002) claim that personal epistemology models such as King and Kitchener's (2004) have been underestimating college students by attempting to classify participants by their lowest displayed level of epistemic cognition. For example, if a participant displays realistic thinking about science, that person has been classified as a prereflective thinker, regardless of any potential quasireflective thinking in areas such as history or political science. Chandler and colleagues suggest that there are further discriminations to be made regarding individual's epistemic cognition. It is important to note, however, that they advocate a middle ground between domain-generality and domain-specificity, classifying academic areas as either ill-structured or well-structured.

Measuring Chandler's Model

The work of Chandler and colleagues (2002) seems to integrate findings from personal epistemology and theory of mind research, but creating a measure for their model has proven difficult. First, initial work assessing students with this model was done using interview techniques very similar to those used by King and Kitchener (1991), with participants presented with two opposing viewpoints and then probed as to how they constructed and resolved the competing knowledge claims (Boyes & Chandler, 1991). While it is certainly possible to train raters to assess students using this model, for large-scale administrations it would be more efficient to develop an objective measure (Wood, Kitchener, & Jensen, 2002). This would allow practitioners the ability to assess students' epistemic cognition and utilize these results to inform their pedagogy.

More recent attempts to validate a quantitative instrument, the Epistemic Doubt Questionnaire (Krettenauer, Hallet, & Chandler, 1999), have revealed that the measure does not accurately discriminate between realism and dogmatism (Hallet et al., 2002). The authors hypothesize that it is difficult to distinguish between the realists, who believe justification is not needed because experience is self-evident, and the dogmatists, who believe that there is no need for justification because some higher authority has special access to truth. While the measure revealed hypothesized differences in levels of skepticism and rationalism between high-school seniors and college juniors and seniors, expected differences were not found between college freshmen, sophomores, juniors and seniors. It is encouraging, however, that the hypothesized relations regarding ill and well-structured domains were supported, with high-school seniors much more likely to be objective about ill and well-structured domains than college students, who tended to be more skeptical regarding both kinds of domains.

Summary

This is not to say that the theory of mind researchers have it right, and the personal epistemology researchers have it wrong. Indeed, both camps can be faulted for ignoring the work of the other (Chandler et al., 2002). In addition, it would be fair to say that both camps also might benefit from more reading of the philosophical work on epistemology, so that they can clarify their definitions and meanings (Kitchener, 2002; Hofer, 2004; Murphy, 2003). Kitchener (2002) advocates for a new hybrid field combining the work of theory of mind and personal epistemology researchers. I believe it is possible to combine the work of personal epistemology and theory of mind researchers to describe a more complete model of epistemic cognition. In addition, the quantitative measures used in the epistemological beliefs literature can be a guide for creating similar measures for this new model.

The Epistemic and Ontologic Cognition Development Model

Personal epistemology and epistemological beliefs models dominate the field of educational psychology, but fail to adequately describe the cognition of people younger than 18-20 year old traditional college students (Chandler et al., 2002). In addition, the measurement of the proposed constructs has proven difficult (Wood & Kardash, 2002). Theory of mind researchers have worked within the human development literature, and while their models do a good job of describing young children's cognition, there are problems with measuring more advanced forms of epistemic cognition (Hallet et al., 2001). Finally, it seems that neither area has done an adequate job integrating work from philosophy, and there still exists an empirical question regarding the level of domain-generality or specificity of epistemic cognition.

I believe these problems can be addressed by focusing on the central question of philosophical epistemology: justification. In addition, the inclusion of Hofer and Pintrich's (1997) nature of knowledge factors as ontologic influences, not epistemic ones, will further help discriminate between various kinds of thinking about knowledge. Here, I outline my Epistemic and Ontologic Cognition Development Model (EOCDM). A delineation of my model requires outlining the areas of knowledge in which development occurs, a review of the stages of development, a description of how ontologic cognition influences thinking in those areas of knowledge, and an explanation of how these dimensions can be measured.

Areas of Knowledge

The level of domain-generality or specificity of personal epistemology is an empirical question. Nonetheless, I believe Buehl and colleagues (2001, 2002, 2005) and

Chandler and colleagues (2002) are correct that thinking about knowledge differs depending upon whether the area is well or ill-structured. Domain-general personal epistemology models are subject to categorizing people according to the domain in which they perform the lowest, and multidimensional models like Schommer-Aikins's are too "diffuse" (Hallet et al., 2002, p. 290). While the basic course of epistemic and ontologic development is the same within well and ill-structured domains, this development occurs in a related, but separate manner.

As children mature, epistemic cognition develops, but in a stage-like manner within each area of knowledge. Movement from the initial position begins at a younger age within ill-structured domains, and does not begin until late in adolescence or young adulthood within well-structured domains. This progression is similar to Kuhn's (Kuhn & Weinstock, 2002) work, but is not as complex as Kuhn's proposed objectivity to subjectivity back-and-forth model. Thus, in essence there are two developmental aspects to my model. There is a progression among domains regarding when cognition begins maturing, starting first with ill-structured domains and then later with well-structured. Likewise, within each of those areas of knowledge, individuals move in a developmental manner through four positions. Those positions are discussed next.

Positions in Development

My model builds off of the stages posited by Chandler and colleagues (2002; Hallet et al., 2002). It should be noted, however, that Chandler and colleagues include a stage, called defended realism, which I do not. I question whether this is truly a "stage" at all, as it does not differ from realism except in the area of taste. Whereas all of the other stages occur independently within domains, defended realism is the only one to describe a specific set of stages *across* domains. I feel this stage does not follow the form of the other stages and is redundant; therefore I have not included it in my model. This leaves my model with four distinct positions: realism, dogmatism, skepticism, and rationalism.

In general, I believe that these positions can be more accurately described and measured by incorporating philosophical work regarding ontology and justification. In terms of describing how to characterize and measure these positions, it is easiest to ignore the distinction of well and ill-structured domains for the moment. In my model, each of the four positions is differentiated according to an individual's views regarding ontology and justification.

Ontology

Realists follow a "copy theory" of the world. These individuals believe there can be no disagreement regarding knowledge that cannot be resolved by an appeal to the facts. In essence, their view of the world, their ontology, is simple and certain. With such a view, epistemic cognition is muted, as justification can be one's own experience, or an appeal to an authority that has had the requisite experience. Individuals can disagree, but one of them is "right" and either direct experience or an authority figure can resolve this disagreement. This view regarding justification is quite similar to that of King and Kitchener's (2004) prereflective thinker and Kuhn's (Kuhn & Weinstock, 2002) absolutist.

If epistemology is really about justification as the philosophers (Williams, 2001) claim, and individuals with a realist ontology have no need for justification, then they are not engaging in epistemic cognition, as Kuhn (1999) and King and Kitchener (2004) have asserted. Realists hold a strong belief in a simple and certain ontology, thus they see both justification by authority as well as personal justification as valid. With a simple ontology, justification of either kind is reasonable but in some ways unnecessary. The true sign that justification, and thus epistemic cognition, has become an issue for individuals is when they adopt a more sophisticaed understanding of the ontology of the world. Only when individuals realize that knowledge is not a direct copy from reality is it possible for them to begin to have epistemic cognition in the way that both psychologists and philosophers conceptualize. For example, a realist would believe that knowing gravity is merely a question of experiencing it, or learning of it from an authority figure. The realist would not question whether gravity truly exists. Instead, the realist would assume that all things in the world, including gravity, are simple to know and certain to stay the same. Asking a realist for justification would bring a quizzical look, and an answer akin to "because that's the way it is" or "because my teacher told me so." To the realist, both responses are equally valid, but in actuality no justification is needed. Every other position in the model, dogmatism, skepticism, and rationalism, has a more adaptive view of ontology, where the world is not simple and certain. To differentiate amongst these positions, then, requires an elaboration of justification.

Justification

The realization that people can legitimately disagree about an area of knowledge brings about a crisis for the individual: knowledge claims are subject to scrutiny. The consequence of this crisis is the first inkling of epistemic cognition: the understanding that knowledge claims must be justified. This forces the person to choose one of two paths to justification.

Confronted with the possibility of false belief, the person can decide that all knowledge in any one area is in fact subjective and personal, making them a skeptic. The other option is for the individual to look to some authority figure for guidance as to what to believe, making the person a dogmatist. These two positions are differentiated in two ways. Skeptics claim that the only justification that matters is personal, and that this personal justification cannot be questioned. Dogmatists are also firm in their belief that justification cannot be questioned, but in their case this justification comes from some authority. Only through an appeal to authority can any belief be substantiated as knowledge. Likewise, the dogmatist discounts personal justification, while the skeptic does not privilege the views of authority. Thus, in terms of acceptable grounds for justification, personal or authoritative, these two groups are polar opposites (see Table 7). For example, in terms of ontology, both the dogmatist and the skeptic might agree that gravity is not directly knowable and thus not evident to all without justification. However, when pressed to justify their "knowledge" of gravity, the dogmatist would produce statements or evidence from authority figures such as teachers or scientists. The skeptic might simply say, "I think gravity exists because I see stuff fall to the ground, I don't need to justify it any other way."

Finally, with development comes the move to rationality, the final position in Chandler and colleagues' model. Rationalists maintain a high need for justification. They see that evidence and support are the means by which knowledge is separated from belief. While they maintain that knowledge is defeasible (Williams, 2001), they allow that individuals must personally evaluate evidence to determine what to categorize as knowledge, and then act upon those justified true beliefs until proven incorrect. However, unlike the dogmatist, rationalists do not believe that the appeal to authority alone is sufficient for justification. Likewise, rationalists do not believe in the multiplicity of the skeptics. Instead, the rationalist looks for corroborating evidence, personal experience, or the logic of the statement before accepting an authority's claim for knowledge. Thus, a rationalist may rely upon personal experience as justification, if it coheres with other experience, or logic. Likewise, the rationalist may depend upon justification by authority to bolster an argument, but only if that authority figure is deemed trustworthy and if the knowledge claim coheres with other knowledge claims. Therefore, rationalists have moderated faith in both authority-based and personal means of justification. Neither is accepted without scrutiny, but likewise both can be acceptable means of justification under the right circumstances.

While I believe that rationalists use both authority-based and personal means of justification, it is not clear that we understand all of the ways in which mature individuals come to a rationalist decision about knowledge. This is an area where King and Kitchener's (2004) and Kuhn and colleagues' (2000) work begins to play a major role, and an examination of the many philosophical theories of epistemology may prove useful (see Murphy et al., 2007).

To finish the example, the rationalist, when pressed to justify a belief in gravity, would most likely produce a number of different mutually-coherent justifications. Perhaps the rationalist would appeal to peer-reviewed science journals, and buttress that argument with examples of gravity's influence upon celestial bodies, or more local ones. The rationalist would acknowledge the possibility that his or her belief in gravity was potentially incorrect or ill-formed, but claim that until shown convincing evidence to the contrary, he or she would claim to "know" about gravity. It is important to note that the

EOCDM is probabilistic, and does not guarantee that all people will achieve a rationalist point of view.

Summary of the Model

Reintegrating the idea of differences in epistemic and ontologic cognition across well-structured and ill-structured domains leads to a full explication of the model. Separately within both domains, I propose that individuals begin in realism, then move to either dogmatism or skepticism, and finally transition to rationalism, although not all people will reach this final position. I also posit that people's position in ill-structured domains will be at least as advanced as their position in well-structured domains. Therefore, while epistemic and ontologic cognitive development occurs separately within each of these domains, they are related. The model can accommodate findings in personal epistemology research as well as those in theory of mind, is consistent with the foci and terminology of philosophical epistemology, and addresses the domain-generality versus specificity issue. However, if this model is to be successful, it must also overcome a challenge confronting both personal epistemology and theory of mind models: measurement.

Measurement of the Model

Schommer-Aikins (2004) says that "quantitative assessment of personal epistemology is still in its infancy" (p. 23). Indeed, the measurement of epistemic cognition has proven difficult (Wood, Kitchener, & Jensen, 2002) and controversial (Hofer & Pintrich, 1997). Some argue for qualitative approaches due to the complexity of construct (Baxter Magolda, 2004; Wood & Kardash, 2002) while others insist that quantitative measures best capture the multidimensional nature of epistemic cognition

(Schommer, 1990). In general, measures of epistemic cognition have proven challenging to create because of semantics, such as the ways that participants interpret words such as "truth" and "facts" (Alexander et al., 1998; Wood, Kitchener, & Jensen, 2002), content concerns regarding possible domain effects (Hofer & Pintrich, 1997), and practical issues such as the time and expense necessary to train raters to administer and score qualitative measures. My model addresses these concerns by positing that the four positions can be measured using three latent factors or continua. These continua can be measured using Likert-style items in a questionnaire format, with attention paid to the language used (Alexander et al., 1998) and separate items for ill-structured and well-structured domains (Buehl et al., 2001, 2002).

In my model, individuals can be placed in one of the four positions of epistemic and ontologic cognition based upon their views on three continua. These continua involve the nature of knowledge factors combined into a single continua measuring a person's ontology and two continua concerning the central question of philosophical epistemology: justification (Pollock & Cruz, 1999; Williams, 2001). The instrument used to measure my model will focus on these three continua, and evidence of construct validity of these continua can be taken as support for the underlying model.

Epistemic cognition cannot begin until the person takes a more mature view regarding the simplicity and certainty of knowledge, recognizing that knowledge claims require justification. Thus, the ontologic continuum discriminates between realists and all other positions. Realists would score highly on questions designed to assess a belief in simple and certain knowledge, whereas individuals in any of the other positions would score lower on these items. The first epistemic continuum concerns whether the person believes justification by authority is valid, whereas the second concerns whether the person feels personal justification is sufficient. These two continua discriminate between dogmatists, skeptics, and rationalists. The dogmatist would score high on the authority continuum and low on the personal, with the skeptic the opposite. The rationalist, with a greater appreciation for both kinds of justification, would score moderately high on both continua, acknowledging that these means of justification are important, but rarely sufficient in and of themselves.

By utilizing these three ontologic and epistemic continua, my model classifies people as being in one of Chandler's four positions (see Table 7).

Table 7

Discrimination of Position by Ontologic and Epistemic Dimensions

Belief in / *Position*	Simple and Certain Knowledge	Justification by Authority	Personal Justification
Realism	High	High	High
Dogmatism	Low	High	Low
Skepticism	Low	Low	High
Rationalist	Low	Mid	Mid

Realists see the world as simple and certain, thinking that justification is not truly necessary, but do see authority figures and personal statements as sufficient for justifying claims, particularly those with which they do not have direct experience. People in all of the other positions believe the world to be complex and changing and thus have a low score on the simple and certain continuum. Dogmatists believe justification is necessary because human interpretation cannot be trusted, and they turn to authority figures for that justification. Skeptics, on the other hand, believe that justification is personal, and that no one can truly know another's experience, nor refute it. Finally, rationalists believe justification to be necessary but do not see an appeal to an authority figure or personal experience alone as sufficient for this justification. A rationalist would want more evidence to support any knowledge claim. Thus, rationalists will score moderately high on both continua, recognizing that these types of justification can be sufficient, but often require corroborating evidence.

I believe that a test of the construct validity of my model will be whether I can create an instrument that successfully measures individuals' beliefs on these three continua, and places people into one of the four categories of epistemic cognition. An individual will have a position for ill-structured domains, and another for well-structured, with the former always being at least as high as the latter. Thus, another means of substantiating my model will be through positing that a developmental sequence across areas of knowledge will hold. For example, I propose it is not possible for one to be a skeptic when it comes to ill-structured domains but a rationalist when it comes to well-structured. In this way, my model posits two developmental progressions, both within areas of knowledge and between them (see Table 8).

Table 8

Hypotheses Regarding Age, Position of Epistemic and Ontologic Cognition, and Score on the Three Dimensions by Domain

	Ill-Structured Domains				*Well-Structured Domains*			
Age	*Position*	*SC*	*JA*	*PJ*	*Position*	*SC*	*JA*	*PJ*
4-12	Realism	High	High	High	Realism	High	High	High
12-Early College	Dogmatism	Low	High	Low	Realism	High	High	High
	Skepticism	Low	Low	High				
Mid to Late College	Rationalism	Low	Mid	Mid	Dogmatism	Low	High	Low
					Skepticism	Low	Low	High
Graduate Education	Rationalism	Low	Mid	Mid	Rationalism	Low	Mid	Mid

SC = Simple and Certain Knowledge Dimension; JA = Justification by Authority Dimension; PJ = Personal Justification Dimension

Therefore, my model makes a direct hypothesis regarding the domain-generality and specificity debate in personal epistemology research (Pintrich, 2002). This conceptualization clearly follows from philosophical epistemology, and the work of Buehl and colleagues (2001, 2002, 2005) as well as Chandler and colleagues (2002; Hallet et al., 2002).

In addition, I have utilized the findings from theory of mind research (Chandler et al., 2002; Flavell, 2004; Hallet et al., 2002) to make predictions regarding when transitions between positions are likely to first occur. Within ill-structured domains, the transition from realism should occur at or after age 12, whereas in well-structured domains this transition is not expected before mid-college (see Table 7). Rationalism is not expected before mid-college for ill-structured domains, and not until graduate school for well-structured domains. These predictions in theory of mind research derive from beliefs about Piagetian cognitive development, but the rationale as to why I chose to use educational level rather than a more direct measure of Piagetian cognitive development follows.

Predicting Development: Educational Level as a Proxy

Many developmental psychologists (Chandler et al., 2002; Flavell, 2004; Hallet et al., 2002) posit that true epistemic cognition does not begin until the development of formal operations as outlined by Piaget (1972). Thus, it would seem beneficial to include a measure of Piaget's cognitive development theory with my questionnaire to test the hypotheses regarding when individuals are likely to progress into a different position. However, Piaget mainly advocated interview methods for his theory, and attempts at creating paper-and-pencil measures of formal operations have been plagued with difficulties regarding reliability and validity (Patterson & Milakofsky, 1980; Pratt & Hacker, 1984; Santmire, 2004; Stefanich, 1983).

For example, Patterson and Milakofsky (1980) critiqued 17 pencil-and-paper measures of Piaget's theory, and found that most failed to measure their intended stages, required advanced language and reading skills, were limited in terms of the ages for which they were appropriate, took too long to administer, and rarely reported reliability or validity information. Their own investigation into one of these measures revealed low reliability of scores for certain age groups, and failed to demonstrate construct validity evidence.

Specific analyses of the more popular measures of Piaget's theory have also uncovered problems with reliability and validity. Arlin's (1982) Test of Formal Reasoning has shown reliabilities below .7, calling into question the validity of the scores given that those scores cannot be valid if they are not reliable (Crocker & Algina, 1986). Arlin's measure has also been questioned by Hagborg and Wachman (1992) who found that the instrument lacked criterion validity when used to predict both the identification of accelerated mathematics students and academic performance. Pratt and Hacker (1984) examined the factor structure of Lawson's (1978) test of formal operations using a Rasch model, and found evidence that the instrument was not unidimensional as predicted. Stefanich and colleagues (1983) examined three popular tests of formal operations, including Lawson's, and found that each measure only agreed with trained rater interview results 50 percent of the time.

In general, these findings suggest that an acceptable paper-and-pencil measure of Piaget's theory currently does not exist. Thus, no such measure will be included in this dissertation. Without this measure, there exists the possibility that age, cognitive ability, and educational level may be confounded in this dissertation. For this dissertation, I will be using educational level to predict individual's positions in well and ill-structured domains. Future research, perhaps including more reliable interview methods of Piaget's theory, will be needed to untangle these issues. This dissertation must be constrained in this, and other, ways.

Relations to Other Personal Epistemology and Philosophical Work

The EOCDM borrows and integrates concepts from personal epistemology, philosophy, and theory of mind work. My model builds off of the general progression of beliefs about knowledge first outlined by Perry (1990). Perry's dualists believe that knowledge is factual, much as my model's realists do. Likewise, in Perry's model the relativist adopts more complex standards for justification, as do rationalists. King and Kitchener's (2004) focus on justification fits well with my model. In particular, the prereflective student in King and Kitchener's model views all problems as well-structured with a clear answer, just as I posit realists view the world. The prereflective student's appeal to authority to resolve disagreements is in line with dogmatists in my model. The quasireflective student in King and Kitchener's model would be categorized as a skeptic in my model, with both believing that justification is personal. Finally, a person with reflective judgment can utilize an authority figure as justification, so long as that person has been critically evaluated. In my model, the rationalist can make a similar justification claim. Baxter Magolda's (2002) independent knower is quite similar to the quasireflective student in King and Kitchener's model, and my skeptic. In terms of Hofer and Pintrich's (1997) epistemological theories, while I applaud their focus on justification, I question their source continuum. Whereas they believe there is an inverse relation between seeing the source of knowledge as the self versus seeing it as an authority, I posit that these are two independent continua regarding the legitimacy of these sources of justification.

Both Kuhn's (Kuhn & Weinstock, 2002) as well as Chandler and colleagues' (2002) model emphasize the importance of examining epistemic cognition by content areas, although not at so domain-specific a level as Hofer (2004) or Buehl and colleagues (2002). I have chosen to adopt this position between the unidimensional models' domain-generality and the more extreme versions domain-specificity advocated by Hofer and others. Buehl and Alexander's (2005) findings regarding the clustering of epistemological beliefs are more similar to my view.

Both Hofer and Pintrich (1998) as well as Schommer-Aikins (2004) emphasize quantitative measures of the nature of knowledge, but in my model I have clarified these as ontologic beliefs, and utilized them to differentiate realists from dogmatists, something with which Chandler and colleagues have struggled. However, I have incorporated many other aspects of theory of mind models, particularly Chandler and colleagues'. Finally, I have utilized philosophical work in epistemology to clarify the definitions used in my model, the constructs that should be considered epistemic, and the role of skepticism as a better description for those who Perry would call multiplists. I believe my model represents an important step forward both in terms of bringing together past work and presenting new opportunities for research, particularly in terms of measuring ontologic and epistemic cognition.

Summary

In sum, my model seeks to reconcile concerns with previous personal epistemology models regarding the seemingly counterintuitive epistemic status of traditional college age students. It does this by integrating theory of mind research into personal epistemology theory. However, the measurement difficulties associated with Chandler and colleagues' model have been resolved by focusing more on the central question of philosophical epistemology, justification, as well as the clarified role of ontology. The domain-generality or specificity controversy in personal epistemology is also addressed in my model, with support from philosophy, the work of Buehl and colleagues (2001, 2002) and theory of mind research. By positing dimensions that can be measured using quantitative techniques, I should be able to categorize individuals' epistemic and ontologic cognition. That cognition is dependent upon the nature of the domain being evaluated, and by considering this factor my model accounts for the disparate findings of previous measures, both in terms of overall level of development as well as the concerns about domain-generality versus specificity. Finally, my emphasis on philosophical epistemology has allowed me to clarify the role of the nature of knowledge dimensions of Hofer and Pintrich (1997) and properly position them as ontological, not epistemological. This further clarification will also aid in producing an instrument that has strong construct validity.

CHAPTER 3: PILOT STUDY

Overview

Given the importance of developing a psychometrically strong instrument to measure epistemic and ontologic cognition with middle-school students through adults, a pilot study was conducted. Pilot studies can help researchers determine whether participants understand and follow instructions and if participants interpret items in the manner in which they were intended. They can also help researchers gain an initial idea of whether the instrument is discriminating between groups as desired (Cone & Foster, 1993). A draft version of the Epistemic and Ontologic Cognition Questionnaire (EOCQ) was produced (see Appendix A) and administered to a convenience sample of three graduate, three undergraduate, four high-school, and three middle-school students, all from an urban area in the Mid-Atlantic region. These data were analyzed in both quantitative and qualitative manners to inform the creation of the version of the EOCQ to be used in this dissertation.

Research Questions and Goals

The main goal of this pilot study was to gain qualitative information regarding how participants were interpreting the items on the EOCQ. Thus, one research question was whether the items were tapping the latent constructs for which they were designed. A second goal of this pilot study was to examine participants' scores on each item, to see whether educational level appeared associated with epistemic and ontologic positions within academic content areas as predicted. In my model I predicted that middle-school students would be realists in both ill and well-structured domains. High-school students were hypothesized to be dogmatists or skeptics for ill-structured domains and realists for well-structured domains. According to my model, college students should be rationalists in ill-structured domains and dogmatists or skeptics in well-structured domains. Finally, graduate students were hypothesized to be rationalists in both ill and well-structured domains.

Method

Pilot Instrument

The pilot instrument (see Appendix A) was designed to measure the three dimensions of the EOCDM: simple and certain knowledge, justification by authority, and personal justification. In addition, items were needed to assess these dimensions in three areas: aesthetics (not analyzed here), ill-structured domains, and well-structured domains. Thus, dimensions were fully crossed with content areas, necessitating nine types of items. Numerous items were created for each dimension/content area set with the intention that some items would be dropped based upon the results of the pilot testing.

Content Areas

For ill and well-structured domains, I sought out academic areas that matched Hallet and colleagues' (2002) assertion that "the long-standing, if somewhat controversial, distinction between the social and natural sciences…is, we think, another instantiation of the difference between" (p. 293) ill and well-structured domains. I chose academic areas I thought would be familiar to each age group: natural sciences such as physics and mathematics for well-structured domains; and social sciences such as history and political science for ill-structured domains.

Dimensions

Simple and certain knowledge. Given that the simple and certain knowledge dimension derives directly from the work of Schommer (1990) and Schraw and colleagues (2002), it seemed natural to examine their instruments for potential items. A review of item functioning, including both quantitative measures such as factor loadings reported in previous studies (Bendixen et al., 1998; Greene et al., 2006; Schraw et al., 2002), as well as more general interpretations of content validity, led to the inclusion of three items from the EQ and the EBI. These items were adapted from their domain-general phrasing in the EQ and EBI to phrasing appropriate for ill and well-structured domains. The original items and their ECOQ versions can be found in Table 9.

Table 9

Items adapted from the EQ and EBI for inclusion in the EOCQ

EQ/EBI Wording	*ECOQ Wording*	
	Well-Structured Domain	*Ill-Structured Domain*
If two people are arguing about something, one of them must be wrong.	If two [scientists, mathematicians] disagree about some part of [physics, math] one of them must be wrong.	If two [historians, political scientists] disagree about some part of [history, political science] one of them must be wrong.
What is true today will be true tomorrow.	In [physics, math], what is true today will be true tomorrow.	In [history, political science], what is true today will be true tomorrow.
Sometimes there are no right answers to life's big problems.	There are some things in [physics, math] that we will never understand.	There are some things in [history, political science] that we will never understand.

The "simple" aspect of the simple and certain dimension was supplemented with other items designed to test participants' views regarding the nature of knowledge in each content area. Multiple items referred to "truth" or "facts," including whether the truth meant different things to different people and whether facts were all that was needed to succeed in school. Items concerning whether things will always be true in the future and whether facts can change were included to measure the “certain” aspect of this dimension.

Justification by authority. For the justification by authority dimension, items focused on participants’ views regarding teachers, domain experts, and classroom learning. The purpose of these items was to determine just how much faith the participants put into authority figures, and the degree to which they accepted, without question, the claims made by those authority figures. Items regarding the authority of textbooks were also included as a way of assessing a more non-human manifestation of authority.

Personal justification. Items for the personal justification dimension proved the most difficult to draft. Items chosen for inclusion in the pilot EOCQ focused upon personal beliefs in content areas and whether others could disprove those beliefs. In addition, an item was included that was reverse-coded, intending to measure whether participants believed that individuals had the ability to justify knowledge qua knowledge at all (see numbers 27, 28, 55, and 56 in Appendix A).

Response Scale

All items were measured on a Likert-type seven-point scale with completely disagree coded as a one, neither disagree nor agree coded as a four, and completely agree coded as a seven. Items were phrased strongly to ensure that participants’ degree of belief in the item would be captured in their choice of response option, and not confounded by item language (DeVellis, 2003). Numerous items were reverse-coded to test whether participants were mindful of the scale when responding. A total of 68 items were created for assessing the nine dimension/content areas, and five demographic items were listed at the end of the EOCQ, bringing the total to 73 items (see Appendix A).

Participants

Participants were gathered using convenience sampling during the Spring semester and Summer of 2006. Graduate students in the Department of Human Development at the University of Maryland, and undergraduates working in that department, were asked to participate. High-school students included two students from a high-school in Montgomery Country, Maryland, a student attending a private school in Washington, DC and another student attending a Maryland military school. Middle-school students were solicited through acquaintances, and included students from two different Maryland counties and three different schools, two attending public schools and one attending a private school. General information about these participants can be found in Table 10.

Table 10

Pilot Participant Information

Participant Number	*Education Level*	*Sex*	*Age*
01	Undergraduate	Male	18
02	Graduate	Female	28
03	Graduate	Female	31
04	Undergraduate	Male	21
05	High-school	Male	18
06	High-school	Female	17
07	Graduate	Male	30
08	Undergraduate	Female	22
09	High-school	Male	17
10	Middle-school	Male	10
11	High-school	Male	16
12	Middle-school	Male	10
13	Middle-school	Male	10

Procedure

All participants indicated their consent before participating, and those under 18 years of age also obtained consent from a parent as well as filling out an assent form themselves (see Appendices B through D for these forms). The assent form described the study to the younger participants, making clear they could stop at any point and asking them to sign indicating they understood what would be asked of them during the study. Participants were tested individually. At the beginning of the session the experimenter explained that the purpose of the activity was to both examine the participant's understanding of various kinds of knowledge as well as to learn more about how participants interpreted the items on the questionnaire. It was stressed that there were no "right" answers to the items, and that if an item was not clear that it was not an indication of any deficit on the part of the participant, but rather a problem with the item itself.

After answering any initial questions, the experimenter asked the participant to put on a microphone so that he or she could be audiotaped while filling out the questionnaire. To better understand how the items were being interpreted, participants were also asked to "think aloud" while filling out the questionnaire (Ericsson & Simon, 1993). This involved the participant saying everything he or she was thinking. Participants were encouraged to verbalize their understanding of each item as well as what they thought as they determined how to respond to the item. If a participant was silent for more than three seconds, the experimenter prompted, "Can you say what you are thinking?"

The questionnaire was administered in paper-and-pencil format. Participants were given as much time as they wished to fill out the questionnaire. After completing the questionnaire, the experimenter followed a semi-structured interview format, asking questions regarding how difficult the questionnaire was to fill out, whether any items were particularly difficult to understand, whether the response scale was sufficient, and if there were any other information the participant thought it important to share.

Data Analysis and Scoring

Qualitative

Qualitative analyses involved first transcribing the audiotapes in their entirety. This produced 190 (M = 14.6) single-spaced pages of text with 6,408 (M = 493) lines and 53,889 (M = 4,145) words. Next, participants' think aloud data, as well as their semi-structured interview responses, were separated and organized by item to facilitate item analysis. Think aloud procedures have been endorsed as a way of assessing how the items are being interpreted and as a means of providing information to help in the rewriting of items (DeVellis, 2003). In this study, think aloud data plus the experimenter's own notes were used to assess each item individually.

Quantitative

All questionnaire responses were entered in SPSS version 11.0.4. Due to the small sample size of this pilot, many statistical analyses such as t-tests, ANOVAs, and factor or reliability analyses were not feasible. Even item means by educational level would serve little purpose. Instead, individual participant responses were examined. All reverse-coded item responses were reflected before analysis (see Appendix A). Classification of participants into one of the four positions of epistemic and ontologic cognitive development was predicted to vary based upon the participant's educational level, as shown in Table 8, previously. For example, middle-school students were predicted to be realists in terms of well-structured domains. Therefore, the model would predict that these participants would have higher scores on the simple and certain knowledge dimension than other participants, and relatively high scores on the justification by authority and personal justification dimensions.

Results

General comments about the testing procedures and the instrument will be presented first, followed by specific reviews of each relevant item.

Thinking Aloud with Middle-School Participants

All of the middle-school students had extreme difficulty thinking aloud while filling out the questionnaire. In each case, repeated requests for students to "say what [they were] thinking" were followed by silence or a simple verbalization of their numeric response. It seemed that thinking out loud presented too much cognitive load for these students. Therefore, the experimenter took detailed notes of participant responses and after their completion of the questionnaire, directly queried the middle-school students about their responses to many items. All other participants were able to think aloud while completing the questionnaire.

Physics and Political Science

Upon testing the middle-school participants, it became readily apparent that any instrument used with this population could not include items about physics or political science. These students simply had not had courses in these areas yet, could not speculate about knowledge in these areas, and indeed often did not know what the words "physics" or "political science" meant. The following dialogue illustrates this, and is typical of transcripts from the other middle-school students:

> **P10:** Some of the questions I didn't understand - the political science.
> **JG:** Okay, good, um what, what didn't you understand or why were they why were they hard for you?
> **P10:** Um well, I haven't done political science in school yet.
> **JG:** Okay.
> **P10:** Um…
> **JG:** So you haven't done it so it was hard, was it hard trying to guess?
> **P10:** Yeah.
> **JG:** What you like…
> **P10:** Mmm.
> **JG:** Okay, what about physics?
> **P10:** I haven't done physics in school either, but I can have an idea of what it's like.
> **JG:** Mm-hm okay, and what do you think it's like?
> **P10:** Um….it's like I think it's like learning a life, like how you're live your life, I'm not sure.

Some high-school students also struggled with these areas:

> **JG:** Okay, so first of all what were your overall impressions of filling this out?
> **P11:** I don't know, I have no idea what political science.. and I haven't taken physics so, I have no idea what, I didn't really know what to put for those.

Even some graduate students sometimes struggled with the items addressing these content areas:

> **P02:** Um, I..had…some trouble with the subjects. You know like I mentioned, I think, it's been so long since I've taken physics, so I was trying to think about, you know, um, physics formulas and the little ramps, and like doing all the different kinds of formulas and equations and proofs, um, so I had trouble sort of situating my thinking in, within that topic. And again, as I mentioned, I hadn't taken a political science course, I don't think, so thinking about that as a topic, um, was a little bit of trouble for me, I think it was easier for me with the math and the history.

Given these difficulties and the need for the EOCQ to have the same items across educational levels, the decision was made to drop all items referring to physics and political science. In the interest of brevity, items addressing these academic areas will not be discussed further in this analysis.

Reverse Coding and Negatives

As DeVellis (2003) has suggested, the reverse-coded items posed problems for many pilot participants. Many of these items included the word "not" and some had double negatives (see Appendix A, item number 65 for an example). Graduate and undergraduate students were able to understand the items, but with some difficulty. The following quote was typical:

> **JG:** Okay okay..um were there any items that you kind of didn't understand, or didn't make any sense to you?
> **P01:** Um there might have been one or two but nothing was so bad that it sort of jumps out at me, just sort of like the wording with a lot of nots and completely disagree or agree I have to think about it for a second.

Younger participants had an even more difficult time with these questions.

> **JG:** Okay, good, okay, and the last one that I saw, that I thought might be confusing for you is 65.
> **P09:** Yeah there was one, like, double-negative.
> **JG:** Yeah.
> **P09:** Yeah that one. [laughs] I was really lost on that one.

JG: Okay so the double negative was what confused you.
P09: Yeah, pretty much.

Therefore, the dissertation version of the EOCQ was written without double negatives and with an effort to reduce the use of terms such as "not." The number of reverse-coded items was reduced, and those items made more clear by eliminating negatives.

Response Scale

Each participant was asked whether the seven point Likert scale was both interpretable and sufficient. All participants agreed on both counts. However, it was often noted that when participants were unsure as to the meaning of the item, they selected neither disagree nor agree. This kind of equivocation is not what the response option was intended to measure, but is often found when there are an odd number of response options with a true neutral point (DeVellis, 2003). While it is hoped that the unclear items have been clarified in the final version of the EOCQ, it is important to try to prevent participants from using the true neutral as a proxy for a "I don't understand" response. Therefore, the response scale on the final version of the EOCQ was changed to a six-point scale, with the options: completely disagree, mostly disagree, somewhat disagree, somewhat agree, mostly agree, and completely agree (see Appendix E).

Ill-Structured Versus Well-Structured Domains

High-school students did seem to see a difference between social sciences and hard sciences, as Chandler and colleagues (2002) would suggest:

JG: So, let me just ask you this question in general, um if you think about like, math or history for example, some people will um talk about how much of it is opinion versus how much of it is fact, so for math how much do you think is fact and how much do you think is opinion?
P11: Math? I think everything is fact.
JG: Okay, so it's almost entirely facts.
P11: Yeah.

JG: What about history?
P11: History is based off of I think a lot of opinion.
JG: Okay, so more opinion than fact in history? Okay good, that's really helpful.

An interesting finding of the pilot, however, was that two of the middle-school students also showed an understanding of subjectivity in history, something the model would not predict. The following two dialogues were instructive:

JG: Okay, great. Um…let's see…so..for *in history the truth means different things to different people* you put a five, why did you put that?
P10: Because um…with the civil war, um, some, all of the Americans think that um..we uh, we were like, yeah, we were like really good.
JG: Mm-mm.
P10: To, yeah, to…to do that, to start a war because it wasn't fair.
JG: Mm-mm.
P10: But some, some people in England probably thought, maybe the opposite of that.
JG: Oh, okay, oh the American Revolution?
P10: Yeah, American Revolution.
JG: Right okay.
P10: That's it.
JG: So, um, so if in America people thought they were doing the right thing but in England people may have thought they were not doing the right thing?
P10: Yeah.
JG: Okay, and um, is one of those groups more right or more wrong?
P10: Um…no.
JG: No.
P10: No, cause..also in the Civil War too, because slaves, the slaves, some people thought it was good to have slave but some people thought it wasn't right.
JG: Okay, and there's not kind of a right or wrong answer?
P10: Yeah.

JG: Okay, great, okay..alright so for this question: *In history, the truth means different things to different people* you said neither disagree nor agree, why did you say that?
P12: Because some people's opinions on like World War II would be that…Hitler was a very good man, now personally I really hate Hitler.

It was readily apparent that in both these cases the participant understood that people view history differently depending upon their perspective. These students appeared to be very bright and perhaps therefore atypical, but it will be interesting to see if whether in a larger sample the characterization of middle-school students as realists when it comes to ill-structured domains will be borne out. The other middle-school student had responses more in line with the model.

Simple and Certain Knowledge Items

Table 11 shows each participant's score on the simple and certain knowledge items. Higher scores indicate greater belief in simple and certain knowledge, a less adaptive position. All reverse-coded items have been recoded so that higher scores represent greater belief in simple and certain knowledge. In addition, the participant's educational level is shown, along with a column indicating the hypothesized score for that participant based upon educational level.

Table 11

Participant Scores on Simple and Certain Knowledge Items

Math							
Educational Level	*Hypothesized SC score*	*Item 2*	*Item 4*	*Item 6*	*Item 8*	*Item 10*	*Item 12*
Graduate	Low	5	3	6	6	3	2
Graduate	Low	2	1	2	3	6	2
Graduate	Low	3	5	7	7	4	1
Undergraduate[a]	High	2	2	6	7	3	3
Undergraduate[a]	High	7	3	6	7	2	7
Undergraduate[a]	High	7	4	6	6	5	5
High-school	High	4	6	6	5	7	4
High-school	High	7	7	6	4	7	7
High-school	High	6	3	6	6	6	2
High-school	High	3	2	7	7	3	7
Middle-school	High	5	5	7	7	1	4
Middle-school	High	4	7	7	7	3	5
Middle-school	High	-	4	7	4	5	7

History							
Educational Level	*Hypothesized SC score*	*Item 29*	*Item 31*	*Item 33*	*Item 35*	*Item 37*	*Item 39*
Graduate	Low	1	4	3	4	1	1
Graduate	Low	2	1	2	2	3	3
Graduate	Low	1	5	7	7	4	1
Undergraduate[a]	Low	1	6	4	6	2	1
Undergraduate[a]	Low	2	7	4	6	1	7
Undergraduate[a]	Low	2	5	4	4	3	1
High-school	Low	1	2	1	1	1	2
High-school	Low	1	4	1	1	7	4
High-school	Low	2	6	7	6	2	4
High-school	Low	3	7	2	7	2	4
Middle-school	High	3	5	4	6	1	6
Middle-school	High	4	6	7	7	3	6
Middle-school	High	-	7	7	7	4	7

Scores that are opposite of what was hypothesized from the model are highlighted.
[a] These participants were in their first two years of college, so they were classified as "Early College."

These data suggest that items 4, 10, 31, and 35 may be problematic in that they have numerous responses that are not as hypothesized.

For the most part, item number two ("In math, the truth means different things to different people.") seemed to be working well, with 77 percent of the responses matching expectations. Graduate students seemed more likely to agree with this statement, as this think aloud illustrates:

> **P07:** Um..again I'm going to, because of the wording, I'm going to have to agree with this ... Basically, the truth regardless of whether or not it is a fundamental truth, can be interpreted differently by different people.

Younger participants were more likely to disagree. In terms of the parallel item for history, item 29, it elicited adaptive responses from high-school through graduate students, as expected. However, as stated previously, one of the middle-school students also responded with an adaptive response, while another was so confused that he could not respond to either item. The item was not changed in the final dissertation version of the EOCQ given the positive quantitative and qualitative results for most participants, but the one middle-school student's inability to respond is concerning.

On the other hand, many participants disagreed with item four ("To do well in math class, the main thing you need to do is memorize facts.") not because they had a more adaptive belief in the complexity of math, but because "you only have to remember formulas you don't remember facts" (P06). These participants often referenced other aspects of the class as more important than facts, but the intention of the item was to assess whether participants understood that the interconnections and interpretations of knowledge were more important. The parallel item in history, item 31, had a different problem. Numerous undergraduate and high-school students, expected to have an adaptive response, instead agreed that in history classes, memorizing facts is all that is required. For example, participant one said: "I know you're supposed to memorize interpretations and stuff like that, but, it's mostly about facts, it's about who what when, where and why and those are all facts." This appeared to be a commentary upon history assessment, and not the area of knowledge itself. The quantitative data also suggest this item is not functioning as intended, with only 58% of the responses as predicted. To address these two problems these items were changed to read: "To know [math/history] well, you need to memorize what you are taught." This change is intended to put the focus of the question back upon whether the knowledge in each of these areas is distinct and whether personal interpretation is not necessary, i.e. simple and certain.

Item six ("In math, what is true today will be true tomorrow.") discriminated between the rationalism of a graduate student and the dogmatism of a college student, respectively, as these two quotes show:

> **P03:** Well, 2 and 2 will always be true but some of the more complicated stuff probably not, so, about a 2 [Participant is referring to her response being disagree].
>
> **P04:** Uh..I'd say that's a six [agree], uh, because math is usually facts and it's rarely that it gets changed around.

The parallel item for history, item 33, also elicited predicted responses. However, in light of the work of Alexander and Dochy (1995) regarding people's use of different terms for knowledge and beliefs, this item was changed to use the word "fact" rather than "true." Therefore they now read "In [math/history] what is a fact today will be a fact tomorrow." Item eight ("In math, the facts do not change") and its history parallel, item 35, confused graduate students because they interpreted "facts" as something beyond human understanding. Two graduate students' think aloud statements illustrate this:

> **P07:** Um, I would, I would argue that our knowledge of the facts can change but the facts themselves don't change.

> **P02:** Um..hm again it's that idea of what we think are facts or what are actual facts um…I..the facts do not change..I guess when I think of something as a fact it is by definition it is something that does not change…so..I'm going to say 6 for that one.

Clearly there was a problem with the word "facts" so this item was altered to: "[Mathematicians'/Historians'] knowledge of the facts about [math/history] does not change." The choice of the term "mathematician/historian" rather than "our" derives from a problem with items 10 and 37 ("There are some things in [math/history] that we will never understand"). One participant in particular interpreted the term "we" differently than intended:

> **P11:** *There are some things in math that we will never understand* well I know I don't understand some things in math, like half the stuff I don't understand because the teacher doesn't tell you how it works in the real world so I don't understand why I need to learn it.

This participant responded agree, interpreting "we" as "I." Other high-school students strongly disagreed with this statement, as predicted, so it appears that the "we" in this item was troublesome. It is possible the middle-school students made the same interpretation, and if their hypothesized beliefs were indeed that math is simple and certain, this would explain their surprisingly low scores (see Table 8).

For the parallel history item number 37, the middle-school participants seemed to be disagreeing with the statement due to a belief that humans lack a detailed record of everything that has happened in the past. This was not the desired interpretation of the item. The item was intended to assess whether participants believed that some knowledge was so complex (i.e. not simple) that it may exceed human understanding. To better capture this idea as well as avoid any confusion regarding "we," these items were rewritten as: "[Math/history] is so complex that humans will never really understand it."

Finally, items 12 and 39 ("If two [mathematicians/historians] disagree about some part of [math/history], one of them must be wrong") were troublesome because numerous participants said:

> **P07:** You can certainly have a scenario where even two people with expertise could disagree, um, but, both of them be wrong, which would make uh, this a false statement.

This item is a good example of why quantitative analyses alone do not suffice for understanding item functioning, because the participants' scores support the hypotheses. However, the qualitative data are clear. Participants were disagreeing with this statement because *both* experts could be wrong. This item was intended to measure whether participants believed that two experts could disagree but both be "right." These items were not working well and, upon further inspection, also seemed to overlap to some degree with the justification by authority dimension, so they were dropped.

Justification By Authority Items

The quantitative data become even more difficult to interpret with the justification by authority dimension. For both ill and well-structured domains, graduate students were expected to respond in the middle of the scale, operationalized here as three through five. For well-structured domains, undergraduates should have either responded consistently high, making them dogmatists, or consistently low, making them skeptics. High was operationalized as five through seven, low as one through three. For ill-structured domains, both undergraduates and high-school students should have either scored consistently high or consistently low. High-school students should have been realists when it comes to well-structured domains, responding with consistently high scores. Finally, middle-school students should have been realists in both ill and well-structured domains, responding with high scores in both areas. Table 12 lists participant scores by educational level.

Table 12

Participant Scores for Justification by Authority Items

		Math				
Educational Level	*Hypothesized JA score*	*Item 14*	*Item 16*	*Item 18*	*Item 20*	*Item 22*
Graduate	Mid	3	3	2	4	3
Graduate	Mid	2	6	4	6	7
Graduate	Mid	6	6	6	7	3
Undergraduate[a]	High/Low	6	6	6	7	7
Undergraduate[a]	High/Low	4[b]	6[b]	3[b]	2[b]	5[b]
Undergraduate[a]	High/Low	3[b]	6	6	5	5
High-school	High	7	6	3	7	7
High-school	High	1	6	2	7	1
High-school	High	1	6	5	7	7
High-school	High	6	7	7	7	6
Middle-school	High	5	6	3	2	4
Middle-school	High	6	7	6	7	3
Middle-school	High	4	7	2	7	7
		History				
Educational Level	*Hypothesized JA score*	*Item 41*	*Item 43*	*Item 45*	*Item 47*	*Item 49*
Graduate	Mid	3	1	1	3	1
Graduate	Mid	4	4	3	3	4
Graduate	Mid	5	5	6	2	2
Undergraduate[a]	High/Low	6	6	3[b]	6	6
Undergraduate[a]	High/Low	4	6	7	7	3[b]
Undergraduate[a]	High/Low	3	4	4	5[b]	3
High-school	High/Low	4	3	2	2	3
High-school	High/Low	1	5[b]	1	5[b]	2
High-school	High/Low	2[b]	6	4[b]	5	7
High-school	High/Low	6	6	6	6	6
Middle-school	High	5	5	3	3	2
Middle-school	High	6	6	7	1	7
Middle-school	High	6	7	1	7	7

Scores that are opposite of what was hypothesized from the model are highlighted.
[a] These participants were in their first two years of college, so they were classified as "Early College."
[b] These scores were not consistent with the majority of other scores for this participant on this dimension

One general question was whether participant responses would be consistently indicative of either the dogmatism or skepticism positions. For the most part this was found, although one undergraduate was highly inconsistent in terms of mathematics and two high-school students were somewhat inconsistent for history.

Items 14 and 41 ("If a [mathematician/historian] says something is a fact, I believe it") performed as expected overall, and participants appeared to understand the question. An example of how participants' responses were in line with predictions was this high-school student's think aloud:

> **P05:** I complete agree because…pretty much math is, isn't something you can see or feel, it's not really something to be skeptical because when you're taught something, you're taught it, meaning it's something that they made so, from them it's got to be true so you just straight up believe it.

One graduate student, who was predicted to be a rationalist about math, agreed or completely agreed with all but one of the justification by authority items. This was unexpected but his think aloud data showed that he was taking more of a dogmatist perspective:

> **P07:** Um…um again even if it was con- if it contradicted something I believed, um I think I still would, uh, believe it's a fact because of the source. A mathematician clearly has more expertise than I do, um, so I think that, mathematician is a more valid source then say me.

It could be that this graduate student was indeed a dogmatist in terms of math. The parallel history item elicited expected responses. For example, this graduate student was approaching history with a rationalist perspective:

> **P02:** Uh, again it's it's hard to say if this is a person you know who I respect and who I think looks at things from, um, all perspectives and, um….then I'd be more likely to believe it. Um, but I am gonna, I'm going to say three for that I don't necessarily believe it automatically.

Thus, these two items were retained in the dissertation EOCQ as written.

Items 16 and 43 (“I think the things written in [math/history] textbooks are true”) were understood by the participants and their ratings were for the most part as predicted by the model. As mentioned earlier, the same graduate student had more dogmatic faith in math authority figures, including textbooks, providing support for the arguments of other personal epistemology researchers that only a small number of people reach a position such as rationalism (King & Kitchener, 2004; Kuhn, 2000). However, given previous problems with the stem “I think” these items were rewritten as: “Things written in [math/history] textbooks are true.”

The next pair of items was not nearly as successful as the previous sets. Items 18 and 45 (“If my friend and I disagree about something we learned in [math/history] class, we just have to ask the teacher to tell us who is right”) were intended to assess participants’ beliefs about the authority of teachers. Instead, participants more often responded to the idea of whether there was a right answer in those fields:

> **P01:** Again, I’m going to go with six because it’s not like I’m going to argue a math point, one of us is going to be right or wrong, it’s not going to be something that’s completely debatable.
>
> **P02:** I completely disagree with that, um, I think that I could have an idea of what happened [in history], my friend could have an idea of what happened, the teacher could have another idea of what happened and none of us may necessarily be correct.

This type of interpretation is more relevant to the simple and certain knowledge dimension, not justification by authority. Therefore, these items were dropped.

Their responses to items 22 and 49 (“I don’t automatically believe whatever my history teacher tells me”) were more in line with model predictions, and think aloud data showed that participants were focusing on the trustworthiness or authority of the teacher. Participant eight's think aloud for the history item illustrates this:

> **P08:** Um…I think teachers have their own biases that they inadvertently put on what they are saying so I would say 5 towards agree.

However, there were concerns about the negative phrasing of "don't automatically believe," so the items were rewritten as: "If a [math/history] teacher says something is a fact, I believe it."

Finally, items 20 and 47 ("I don't believe everything I learn in [math/history] class") may seem repetitive of the previous items in this dimension, but I believe they tap an overall sense of trust in learning. However, the middle-school students struggled with the phrasing of the question:

> **JG:** Okay this one here, *I don't believe everything I learn in history class*. And you put completely agree, so you don't believe everything you learn in history class
> **P12:** See, I think that was one of the mistakes I made because I had, I think this was when my eye was sort of getting kind of tired, um…because I didn't get, I think, very much sleep I was, I did get a lot of sleep but my eyes are still kind of tired….so, I was, I should have read this and like a second time and then put a better answer like completely disagree because if your teacher tells you that something is a fact they would probably know better because they've gone through this many more times
> **JG:** Okay, so um in history class if a teacher says something is true, you tend to believe your teacher?
> **P12:** Yes

Despite his claims of being tired, it appeared that he got confused regarding the negative. Therefore, this question was rewritten as: "I believe everything I learn in [math/history] class" and is now not reverse-coded.

Personal Justification Items

There are a number of interesting findings among the personal justification items.

First, at a general level, the EOCDM predicts that participants in the dogmatism and skepticism positions should be high on one justification dimension, and low on the other. Looking past the items that have been replaced, of the ten participants in either of these two positions, only two were high on both dimensions (see Table 13). All of the other participants had high scores on one dimension and low scores on the other. This is encouraging in terms of the specific hypothesis of the EOCDM that students in those positions should not have similar scores on both dimensions.

Table 13

Participant Scores for Personal Justification Items

Math				
Educational Level	*Hypothesized PJ score*	*Item 24*	*Item 26*	*Item 28*
Graduate	Mid	3	2	5
Graduate	Mid	1	1	4
Graduate	Mid	3	1	5
Undergraduate[a]	High/Low	2	1	3
Undergraduate[a]	High/Low	3	1	5
Undergraduate[a]	High/Low	2	2	4
High-school	High	4	1	2
High-school	High	1	1	7
High-school	High	1	2	4
High-school	High	2	1	6
Middle-school	High	3	4	5
Middle-school	High	1	1	1
Middle-school	High	-	1	-
History				
Educational Level	*Hypothesized PJ score*	*Item 51*	*Item 53*	*Item 55*
Graduate	Mid	2	2	4
Graduate	Mid	1	1	6
Graduate	Mid	2	2	3
Undergraduate[a]	High/Low	6	1	5
Undergraduate[a]	High/Low	7	2	2
Undergraduate[a]	High/Low	2	4	5
High-school	High/Low	4	6	1
High-school	High/Low	7	1	1
High-school	High/Low	1	2	4
High-school	High/Low	2	1	5
Middle-school	High	2	4	2
Middle-school	High	1	3	2
Middle-school	High	-	1	-

Scores that are opposite of what was hypothesized from the model are highlighted.
[a] These participants were in their first two years of college, so they were classified as "Early College."

However, the other interesting finding is much less positive. From a quantitative point of view, the personal justification items seem to be working quite well for participants hypothesized to be in dogmatism or skepticism, but working very poorly for all other participants. Qualitative data support this conclusion. At the extreme, one middle-school student simply could not answer most of these questions. When asked about why this was so, the student was at a loss to explain himself.

In terms of items 24 and 51 ("In [math/history], you just have to decide what you believe and what you do not") numerous students reacted to the "just" as implying that the scientific method, or other kinds of rigorous thinking, was not useful. For example, this graduate student is thinking in a relativistic manner, but responded with "completely disagree."

> **P02:** Again, when I first read that I feel a little bit more like hmmm, maybe so, maybe you do have to decide what you believe and what you do not, but I don't feel comfortable saying that I agree, I disagree with that. Um, I don't think you just have to decide what you believe and what you do not, I think maybe there's a process that you have to go through um…and..and um…not endorse, or not endorse, but, come to a conclusion through other ways.

A vast majority of the high-school and middle-school students responded to item 24 with slightly disagree or lower, contrary to hypotheses. College students also disagreed, but in their case this met the model's hypothesis, so their responses appear supportive of the EOCDM. However, it is clear that the intention of this item, to assess whether participants viewed personal experience as sufficient for justification, was not communicated. In addition, Alexander and Dochy's (1995) findings would suggest that the word "truth" should be replaced with "knowledge." Therefore, to better tap this construct, this item was completely rewritten as: "In [math/history], everyone's idea of knowledge can be different because there is no one absolutely right answer."

Items 26 and 53 ("In [math/history], if you believe something is true, no one can tell you that you are wrong") also had almost completely opposite results for participants hypothesized to be in realism or rationalism. Many participants reacted to the "no one can tell you that you are wrong" portion of the item in a similar manner, for example:

> **P02:** Again, someone can always tell you that you are wrong, so I'm going to say that I disagree, a 2 for that.

Participants in realism or rationalism focused on the idea that people can be told they are wrong and not whether they can be proven wrong. One high-school student expressed this clearly:

> **P05:** Um…uh…..and also that one thing that I thought could have confused me…was "no one can tell you whether you are wrong or not." Does that mean no one is able to just say you are wrong, or no one will be able to prove and say, "You're wrong for sure?"

However, it is interesting that those participants in the dogmatism or skepticism positions did seem to grasp that the question was intended to assess whether they believed there was an objective right or wrong:

> **P11:** Well, no a historian could tell you if you were wrong so let's go with a two. Well, actually let's go with a one.

So, in an effort to preserve the positive aspects of this item but address some participants' misunderstanding of the word "tell" these items have been rewritten as: "In [math/history], if you believe something is a fact, no one can prove to you that you are wrong." It is important to note that this item does differ from the simple and certain knowledge item "In [math/history], the truth means different things to different people." The personal justification item focuses on whether some can justify their individual belief, whereas that simple and certain knowledge item focuses on whether knowledge is complex and able to be interpreted in different ways by different people.

Items 28 and 55 (“In [math/history], the average person cannot tell what is true and what is not”) were very confusing for participants:

> **P08:** Again, um, average person has to be better defined. Well, if by average person you mean someone who has not taken history at all, yeah, it can have, it’s not if they can say what is true or what is not, they don’t have an understanding.

Numerous other participants had similar struggles, so this item was rewritten to better address this issue of the validity of personal experience in academic areas and the work of Alexander and Dochy (1995): “In [math/history], what’s a fact depends upon a person’s point of view.” Finally, I felt it important to add an item that included both the terms Alexander and Dochy (1995) found most strongly related to knowledge. Thus, I added the items “[Mathematical/historical] knowledge is all factual and there are no opinions.” These items are obviously reverse-coded.

Summary

This pilot study was very helpful in determining which items were working well and which needed to be rewritten or removed. The quantitative data provided an initial insight into how participants were responding by educational level and in terms of the hypotheses of the EOCDM. The think aloud and interview data, however, provided important insight into participants’ interpretations and struggles with the items. Based upon participant responses, the items were refined to be more focused upon the central issues of the three dimensions: simple and certain knowledge, justification by authority, and personal justification. A new, shorter but more focused version of the EOCQ was created for use in the dissertation study (see Appendix E). This dissertation version of the EOCQ contains 26 content items and seven demographic items, making it much quicker to fill out and reducing the resource demands. The title was also changed so that it does not influence any participants who might have familiarity with models of personal epistemology.

CHAPTER 4: METHODS

Chapter 3 provides information regarding the final dissertation version of the EOCQ to be used in this dissertation. This chapter focuses upon the procedures used to administer this measure, how missing data was handled, the coding of educational level, and the analysis plan.

Participants

Participant Recruitment

Professors and instructors from multiple departments at the University of Maryland, including Human Development, Measurement, Statistics, and Evaluation, Counseling and Personnel Services, and the College Park Scholars program were asked if I could enter their classes and administer the EOCQ to their students. I also received permission to enter into English classes at Downingtown West High School in Downingtown, Pennsylvania. Finally, I also drew a sample from the sixth-grade students at Downingtown Middle School in Downingtown, Pennsylvania.

Sample Characteristics

There were a total of 662 participants in this study. Table 14 details the participants by educational level and sex. The total sample was 67% female and 33% male.

Table 14

Participants by Educational Level, Sex, and Age

	Male	Female	Age: Mean (Standard Deviation)
Middle School	52	75	11.57 (.496)
High School	68	105	16.74 (1.066)
Undergraduate	79	225	20.35 (2.804)
Graduate	20	38	28.4 (5.266)

The total response rate across educational levels was 67%. Table 15 shows the response rate by educational level.

Table 15

Response Rate by Educational Level

Educational Level	Response Rate
Middle School	42% (127/300)
High School	62% (173/281)
Undergraduate	99% (304/307)
Graduate	60% (58/97)

The response rate for middle-schools students was particularly low. However, the principal of that school said the low rate may be related to the fact that it is quite difficult for middle-school students to remember to get parental consent forms signed and returned. He stated that a 25 percent return rate was not uncommon for these types of forms (Mr. Tom Mulvey, personal communication, February 8, 2007).

Finally, Table 16 shows the major of the undergraduate and graduate students, crossed with gender.

Table 16

Graduate and Undergraduate Major by Gender

Major and Gender	Gender	Number
Graduate		
Business	Male	3
	Female	0
College Student Personnel	Male	3
	Female	4
Communication	Male	0
	Female	5
Counseling Psychology	Male	3
	Female	1
Measurement, Statistics, and Evaluation	Male	5
	Female	6
Education	Male	1
	Female	2
Educational Psychology	Male	1

	Female	2
Family Studies	Male	0
	Female	1
Human Development	Male	0
	Female	5
Kinesiology	Male	0
	Female	1
Mechanical Engineering	Male	0
	Female	1
Psychology	Male	1
	Female	1
Public and Community Health	Male	0
	Female	2
School Psychology	Male	0
	Female	3
Special Education	Male	1
	Female	1
Undergraduate		
Accounting	Male	1
	Female	4
Aerospace Engineering	Male	0
	Female	1

Allied Health	Male	0
	Female	1
American Studies	Male	0
	Female	2
Animal Science	Male	0
	Female	1
Anthropology	Male	0
	Female	2
Art History	Male	0
	Female	2
Bioengineering	Male	0
	Female	1
Biology	Male	2
	Female	8
Business	Male	4
	Female	4
Cell Biogenetics	Male	1
	Female	1
Chemistry	Male	0
	Female	1
Communications	Male	1
	Female	10

Computer Engineering	Male	1
	Female	0
Computer Science	Male	0
	Female	1
Criminal Justice	Male	12
	Female	9
Criminology	Male	5
	Female	4
Dietetics	Male	0
	Female	1
Economics	Male	9
	Female	5
Education	Male	1
	Female	37
Engineering	Male	0
	Female	1
English	Male	2
	Female	2
Family Studies	Male	3
	Female	6
Finance	Male	4
	Female	2

Geographic Information Systems	Male	1
	Female	0
Government	Male	1
	Female	3
Hearing and Speech Sciences	Male	0
	Female	7
History	Male	0
	Female	2
Journalism	Male	4
	Female	1
Kinesiology	Male	9
	Female	13
Marketing	Male	1
	Female	6
Mathematics	Male	0
	Female	2
Mechanical Engineering	Male	0
	Female	1
Music	Male	1
	Female	0
Neurophysiology	Male	1

	Female	0
Nursing	Male	0
	Female	2
Pharmacy	Male	0
	Female	2
Physics	Male	0
	Female	1
Physiology	Male	0
	Female	4
Physical Therapy	Male	0
	Female	1
Psychology	Male	7
	Female	28
Public and Community Health	Male	2
	Female	13
Social Psychology	Male	2
	Female	1
Sociology	Male	1
	Female	3
Spanish	Male	1
	Female	1
Special Education	Male	1

	Female	7
Theatre	Male	1
	Female	2
Undecided	Male	0
	Female	13
Women's Studies	Male	0
	Female	2

Although there are a proportionally larger number of education majors in the sample, in general the kinds of majors students reported were fairly diverse.

Informed Consent

Participants over the age of 18 were asked to complete the informed consent form immediately before completing the EOCQ. Participants under the age of 18 were asked to take the informed consent form to a parent or guardian to sign. Students brought the consent form to class and this was collected. These participants, under the age of 18, then were given the assent form to read and sign (see Appendix F for scans of the consent and assent forms with IRB approval stamp). Once both the consent and assent forms had been signed, the EOCQ was administered. Any questions about the procedure that did not jeopardize the validity of the EOCQ administration were answered before the participants took the questionnaire.

Procedure

Instructions to Participants

Participants were told "This questionnaire is meant to assess your understanding of different academic and non-academic areas. There are no right or wrong answers. Please answer the items honestly, as your responses will be confidential." The response scale was also described as spanning from one to six, with one being completely disagree, two being mostly disagree, three somewhat disagree, four somewhat agree, five mostly agree, and six as completely agree. Participants were given as much time as they need to complete the EOCQ, contingent upon the time allotted by the instructor of the class in which they are taking the questionnaire. No student took longer than 20 minutes to complete the questionnaire, and none expressed concern that they lacked the time necessary to complete it. Participants filled out the EOCQ individually and were asked to not discuss the questionnaire while completing it. Any content questions participants may have had about items on the questionnaire were not answered to prevent bias. Instead, the participants were told to "do the best [he or she] can" in interpreting the item. After collection of the EOCQ, participants were asked not to discuss the questionnaire with any peers who might be taking it at a later time.

Debriefing

This measure was administered to groups of students in classrooms, not on an individual basis. Therefore, the needs and wishes of the instructor of the class were respected. If time was available for a group debriefing, I gave a brief description of the content of the questionnaire. I also offered individuals the opportunity to contact me via email to arrange a time to debrief individually.

Analysis

The data analysis itself is described in the results section. However, three issues are relevant to the methods used in this study. The first is missing data, next is the measurement of educational level, and the last is statistical power.

Missing Data

Of the 662 participants, only 23 had missing data. There were 16 unique missing data patterns, with no pattern repeated more than twice. Given that this was a low percentage of the total data and that there were no specific patterns that were frequent, the missing data was treated as missing completely at random (MCAR; Little & Rubin, 2002). In Mplus, when the data are MCAR, full information maximum likelihood is used so that no cases need be removed from the analyses (Muthén & Muthén, 2006).

Educational Level

As stated previously, educational level is a proxy for exposure to education, and is conflated with age and cognitive ability. Participants were asked if they were in middle-school, high-school, college, or graduate school. College students were asked whether they were freshmen, sophomores, juniors, or seniors. For analysis, this variable was coded as years of school, with middle-school as 6, high-school as 11, freshman as 13, sophomore as 14, junior as 15, senior as 16, and graduate school as 17, thus making it a continuous variable.

Power

Wood and Kardash (2002) assert that many studies of epistemic cognition lack the power necessary to find statistical significance. This is often due to either a failure to use more powerful statistical techniques or a study having a low sample size. For this analysis I utilized a factor mixture model, which disattenuates error providing a more powerful test of the relations amongst the variables. However, factor mixture models also require larger sample sizes than many other techniques. Unfortunately, sample size recommendations for factor mixture models “are difficult if not impossible to provide” (Lubke & Muthén, 2005, p. 36). Nonetheless, power analysis can provide a rough idea of sample size needs.

The factor mixture model can be considered a kind of mixture structural equation model (SEM), thus the closest means of assessing a priori power is to utilize methods for SEM models such as those described by Hancock (2006). In this case, the power analysis concerned sample size determination for testing data-model fit as a whole. A fully unrestricted final factor mixture model without covariates is the most complex model with the least amount of information, and thus requires the most participants to reach sufficient levels of power. Mixture models require the estimation of both the mean and covariance structure. Hancock (2006) provides a formula for determining the necessary sample size based for the common standard of power: .80. This formula requires knowing the degrees of freedom of the model, which in this case is the number of unique pieces of information in the variance/covariance matrix and the means structure minus the number of parameters to be estimated. Assuming 26 EOCQ items, there would be 351 unique pieces of information. Assuming a four class model with strong factorial invariance and latent factor variances and covariances free to vary across classes, the following parameters would have to be estimated: 20 factor loadings (6 set to 1 for identification), 104 error variances, 52 error covariances, 26 intercepts, 24 latent factor variances, 80 factor covariances, and 12 latent means (6 set to 0 for identification), totaling 318 parameters. Thus the degrees of freedom would be 33. Setting the RMSEA test p-value at $\alpha = .05$ and using Hancock’s (2006) recommendation for the reference distribution’s degree of noncentrality, it was determined that 439 participants would be needed for a level of power of .80. This analysis had 662 participants, clearly exceeding a power of .80.

CHAPTER 5: RESULTS

Description of Analyses

The analyses addressed three main issues. The first concern was the validity and the reliability of scores from the EOCQ. The second concern was the testing of the EOCDM using a factor mixture model. The third concern was the proposed developmental progression of EOCDM positions and its relation to educational level.

Validity and Reliability of the EOCQ

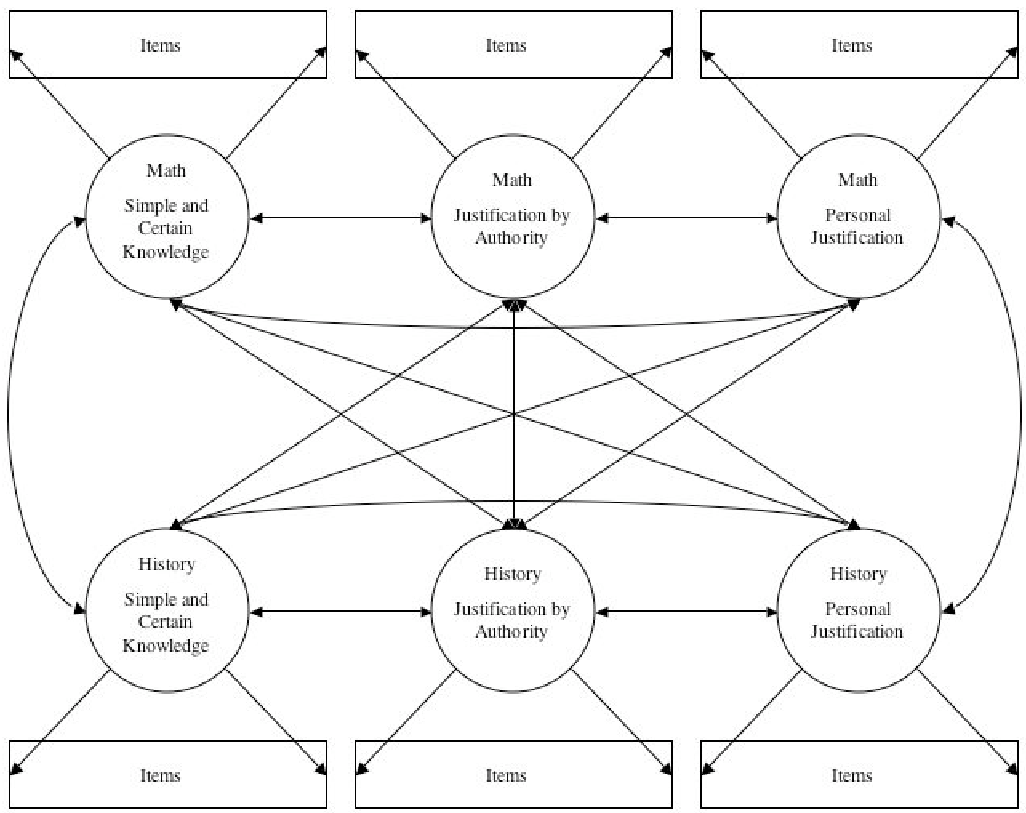
According to the *Standards for Educational and Psychological Testing* (2000), validity is "the degree to which evidence and theory support the interpretations of test scores" (p. 9) and is specific to the sample, the time the sample was gathered, and the conditions of the data collection. As such, all discussions of validity in this dissertation are subject to these conditions. The construct validity of scores from the EOCQ, their reliability, and the viability of the underlying model, was first assessed using a measurement model. These analyses addresses research question one, hypotheses one and two. All analyses were performed using Mplus version 4.2 (Muthén & Muthén, 2006), and full information maximum likelihood estimation due to the MCAR nature of the missing data.

Measurement Model Validity

Using confirmatory factor analysis (CFA), I used the measurement model to examine whether the three dimensions (simple and certain knowledge, justification by authority, personal justification) within each domain (math and history) were adequately captured by their respective items, or indicators. In this model, all latent factors, the dimensions, were allowed to covary (see Figure 2). The possibility of statistically significant error covariances was more likely with the EOCQ given that parallel items were used for math and history (for example, see items 1 and 13 in Appendix E). Therefore, error covariances for each set of parallel items were included *a priori*. These covariances are not shown in Figure 2 for the sake of clarity.

Figure 2

Measurement Model



If found, acceptable fit of the model to the data would provide evidence of the construct validity of scores from the EOCQ. Data-model fit was assessed in multiple ways. The chi-square test of fit was calculated but not used to determine data-model fit due to its sensitivity to sample size (Kline, 2005). Instead, I examined the chi-square/df ratio, the comparative fit index (CFI), the Tucker-Lewis coefficient (TLI), the standardized root mean-square residual (SRMR) and the root mean square error of approximation (RMSEA). Using current standards, the hypothesis of good data-model fit can be retained when the chi-square/df ratio is less than 2.0 (Kline, 2005), the TLI and the CFI are greater than or equal to .96, the SRMR is less than .09 or the RMSEA is less than or equal to .06 (Hu & Bentler, 1999). Hu and Bentler (1999) recommend using the SRMR in combination with either the CFI or RMSEA to determine fit. Successful data-model fit provides support for hypothesis one. A lack of fit does not necessarily imply a problem with measurement. In factor mixture models, it is possible that a CFA might have poor fit specifically because there are underlying mixtures in the sample that have differing relations amongst the items (Dr. Gregory R. Hancock, personal communication, September 11th, 2006). Therefore, construct validity evidence was obtained using both the measurement model and the factor mixture model, described later.

Measurement Model Reliability

The factor mixture model implemented later to test hypotheses about the EOCDM utilized the theoretical latent factor scores as indicators of the latent classes. As such, the reliability of those theoretical latent factor scores was important. The appropriate indicator of reliability for latent factor scores is Coefficient *H,* which is a maximal reliability measure (see Hancock & Mueller, 2001). This reliability measure yields an estimate of the degree to which the latent construct is captured in the information contained in its measured indicators, which in this case are the items. Coefficient *H* also provides a sense of how well this factor would be expected to cross-validate. Hypothesis 1a, that Coefficent *H* will be greater than .7 for each latent factor in math and history in the measurement model, was examined. The value .7 was chosen because it is a commonly accepted lower bound for adequate reliability (Cronbach & Shavelson, 2004).

Domain-Generality Versus Specificity Hypothesis

Hypothesis two was tested by running three comparison models. The first comparison model had a single domain-general factor for the first dimension, simple and certain knowledge. The fit of this model was compared to the fit of hypothesized measurement model. The second and third comparison models had domain-general factors for the justification by authority and personal justification factors, respectively. A scaled chi-square difference test (Satorra & Bentler, 1999) was used to determine whether each comparison model had a statistically significantly worse fit than the domain-specific measurement model. If the fit of each comparison model was statistically significant worse than that of the measurement model, this would provide evidence for retaining hypothesis two, that epistemic and ontologic cognition, as measured by my model, is domain-specific.

Factor Mixture Model

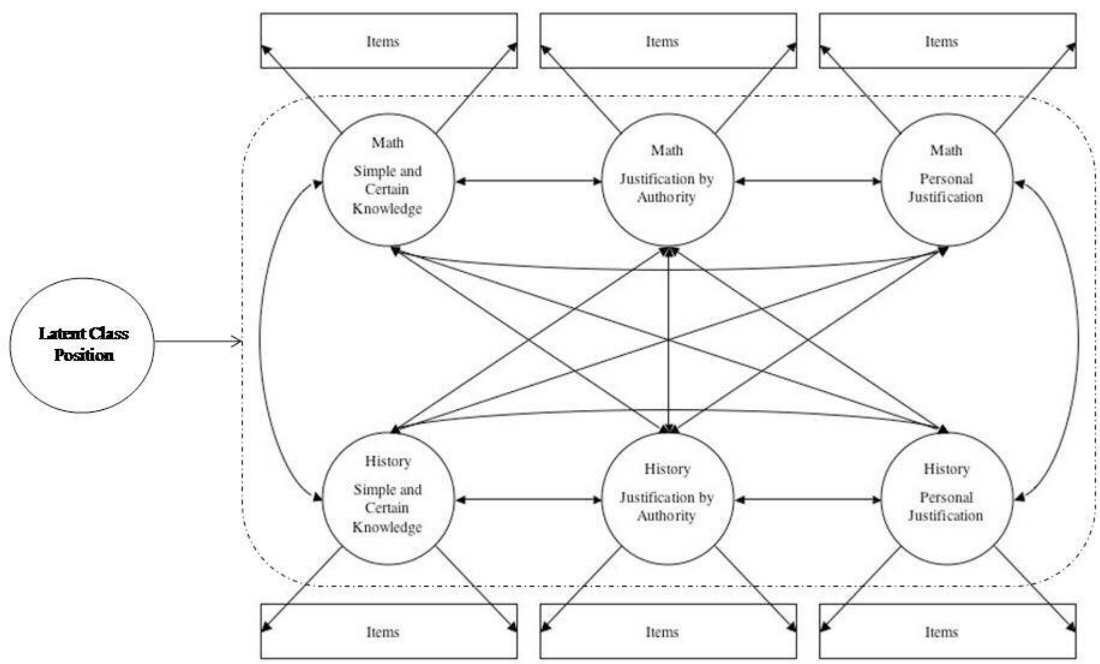
The factor mixture model combined the confirmatory factor analysis used in the measurement model with a latent class cluster analysis using the theoretical latent factor scores. Confirmatory factor analyses disattenuate error in the EOCQ, providing better measures of participants' beliefs to be used in classifying participants as realists, dogmatists, skeptics, or rationalists (Kline, 2005). The main advantage of the factor mixture model is that it provides a confirmatory way of assessing whether these classifications are supported by the data.

The factor mixture model addressed hypothesis three, and was used for hypotheses four and five. Given that epistemic and ontologic cognition position is latent, an individual's position in the EOCDM must be determined from his or her responses to individual items. The factor mixture model provided a way of categorizing participants as realists, dogmatists, skeptics, or rationalists within each domain based upon their responses to individual items. Within both math and history, EOCDM position was defined in terms of scores on the three epistemic and ontologic dimensions (see Table 8). For example, realists in math and history are hypothesized to have relatively high scores on all three epistemic and ontologic dimensions in both domains. Therefore, it follows that realists' theoretical latent factor scores in the measurement model should be at least as high or higher than participants with dogmatic, skeptical, or rationalist beliefs in these domains. A participant's EOCDM categorical position was determined based upon his or her theoretical latent factor scores across all six dimensions.

In terms of statistical modeling, EOCDM position across both math and history can be considered a categorical variable. For example, participants could be categorized as realists in math and skeptics in history, or dogmatists in math and rationalists in history (see Table 8 for a list of hypothesized positions across domains). The classification of a participant on this categorical variable was made through the use of six continuous latent factor indicators: the dimensions (see Figure 3). This kind of analysis can be thought of as akin to a latent profile or latent class cluster analysis (see Magidson & Vermunt, 2004 for a general description of latent class cluster analyses). However, given that the indicators were latent and not observed, Lubke and Muthén (2005) would describe this type of analysis as a factor mixture analysis, and that is how it will be referred to here (see Muthén, Asparouhov, & Rebollo, 2006 for an example of a factor mixture analysis, in this case with behavioral genetics modeling). Factor variances and covariances were allowed to vary across classes. For clarity, factor indicators, the items, and indicator error covariances are not shown in Figure 3, but are the same as shown in Figure 2.

Figure 3

Factor Mixture Model



Whereas in latent class analysis the indicators, in this case the EOCQ items, are often assumed to be locally independent, in factor mixture analysis the covariances of the items are modeled using the latent factors, and these relations are captured in the CFA or measurement portion of the model. The CFA portion of the model disattenuates the measurement error in the items, providing stronger measures of the theoretical latent factor scores to be used as indicators of the latent classes. Therefore, the factor mixture model assessed whether participants clustered into classes according to their theoretical latent factor scores, with the expectation that the class means for each factor would match those hypothesized by the model and illustrated in Table 8. For example, for the ill-structured domain, history, the model suggests that middle-school student means on the three dimensions should all be high, whereas graduate students' latent means should be low on the simple and certain knowledge factor and mid (in the middle of the scale) for the two justification factors. In essence, a factor mixture model is like a multiple-groups CFA where the groups are unknown and must be determined by the data.

However, before latent factor means can be used to typify classes, the factorial invariance of the measurement portion of the model must be demonstrated (Byrne, 1994; Lubke & Muthén, 2005). Factorial invariance has been defined as having three increasingly restrictive levels: weak, strong, and strict invariance (Meredith, 1993). Weak invariance occurs when only factor loadings are fixed across classes. Strong invariance fixes intercepts as well as factor loadings. In addition to the restrictions in strong invariance, strict invariance also fixes error variances and covariances across classes. In general, factor loadings and intercepts must be fixed across classes to use the latent means in the factor mixture, necessitating at least strong factorial invariance. There continues to be disagreement as to whether strong or strict factorial invariance is necessary for factor mixture models (Lubke & Muthén, 2005) but it is becoming more evident that fixing factor loadings across classes helps in the estimation of factor means (Lubke & Muthén, 2007), the focus of this study. This analysis assumed strong factorial invariance was sufficient for utilizing latent factor means, and also assessed whether strict invariance held. Therefore, factor loadings and intercepts were held fixed across all classes, but models with and without error covariances and variances fixed were tested.

Data-model fit for factor mixture models is an unsettled issue in the field (Nylund, Asparouhov, & Muthén, under review). The measurement model assessed the fit of the CFA portion of the factor mixture model. The factorial invariance models (Lubke & Muthén, 2005) assessed whether the models were amenable to using the theoretical latent factor scores as indicators of the latent class variable, EOCDM position. Assessing the fit of the model with the inclusion of the latent class position variable with its latent factor indicators, however, complicated the analysis in two ways. First, the factorial invariance models described previously had to be run anew each time the number of posited latent classes was increased. So, the analyses began with a two latent class model, and models with and without error variances and covariances fixed across classes were fit to determine which model had better fit. Then a three latent class model was examined, again comparing models with and without residual variances and covariances fixed. This process continued through a four latent class model. This resulted in a number of models tested, necessitating some means of choosing the best model. The decision rule used to choose between models is described next.

Further complicating the use of a latent class position variable is that commonly accepted criteria for choosing the best model based upon data-model fit in factor mixture models, such as Hu and Bentler's (1999) for CFA, do not exist. The main concern with the fit of the categorical position variable is how many different classes, in this case EOCDM positions, are appropriate given the information in the latent indicators. Certainly substantive theory should be the main guide, and in this model there should have been at least two classes, one with math and history realists and another with more adaptive positions in these domains. However, it was possible that the data would be better fit with a model with more classes. It was possible to have one class for each model-supported combination of position crossed with domain, leading to a large number of factor mixture models with varying numbers of classes. While the interpretability of the classes is one means of deciding between models, more mathematical criteria are also desirable.

Unfortunately, a model with *K-1* classes is not nested within a model with *K* classes, thus they cannot be directly compared using standard likelihood-ratio tests (c.f. Dayton, 1998). Models differing in the number of classes, however, can be compared using information criteria measures. These measures include the Akaike and Bayesian information criteria (AIC, BIC; Vermunt & Magidson, 2002). These information criteria are designed to select the model that "is expected to show the smallest decrease in likelihood if the model were cross-validated on a new sample of cases" (Dayton, 1998, p. 18). The AIC does not directly take into account sample size, whereas the BIC does and is considered asymptotically consistent. For each measure, the model with the lowest value is considered a better fit. In many cases the BIC tends to favor models with fewer classes than those selected using the AIC (Dayton, 1998). The adjusted BIC (SABIC) has also been recommended as another means of comparing data-model fit across models with different numbers of classes (Nylund et al., under review).

Information criteria measures have been criticized, however, and researchers have attempted to create alternative versions of the likelihood-ratio test as a means of directly comparing models with differing numbers of classes. One such test is the Lo-Mendell-

Rubin likelihood ratio test (LMR; Lo, Mendell, & Rubin, 2001), which tests the null hypothesis that the data are actually the result of *K*-1 classes. Rejection of this null hypothesis supports retaining a model with at least *K* classes, if not more. Recently, Nylund and colleagues (under review) have submitted simulation results suggesting that the parametric bootstrap likelihood ratio test (called the bLRT) is a more accurate test of whether a model with at least *K* classes fits better than a model with *K-1* classes.

Given the still unsettled nature of the field, a decision rule was needed for choosing between models. For this dissertation, I used the following measures to choose between factor mixture models with differing numbers of classes: the AIC, BIC, SABIC, LMR, and bLRT. When these measures differed, a consensus was sought, and barring any consensus, substantive theory and the bLRT were used to make final decisions regarding the best fitting model.

Factor Mixture Model Reliability

During the process of estimating the factor mixture model, it was possible that the factor loadings would be different from those is the measurement model CFA, affecting the measure of reliability, Coefficient *H*. Therefore, hypothesis 3a was used to examine whether the factors in factor mixture model also had a construct reliability of .7 or higher.

Developmental Progression of Math and History Positions and Their Relation to Educational Level

Math and History Position Hypothesis

From the tested models, the best model, as determined using the decision rule described previously, was chosen as the final factor mixture model. Participants were placed into the class for which they had the highest probability. The means of each class's theoretical latent factor scores were then examined and used to characterize the math and history EOCDM position for participants in that class (see Table 7). For example, if a class were to have a high latent factor mean for all six latent factors, this would identify the class as realist for both math and history. Latent factor means are described on a relative scale, meaning that they must be compared to means in other classes to determine whether they are high, mid, or low. With hypothesis four, I predicted very specific combinations regarding latent factor means within domain, thus this hypothesis could be retained or rejected based upon whether the pattern of factor means matched those stated in Table 7. In addition, it was hypothesized that a latent class's history position would always be at least as adaptive as its math position.

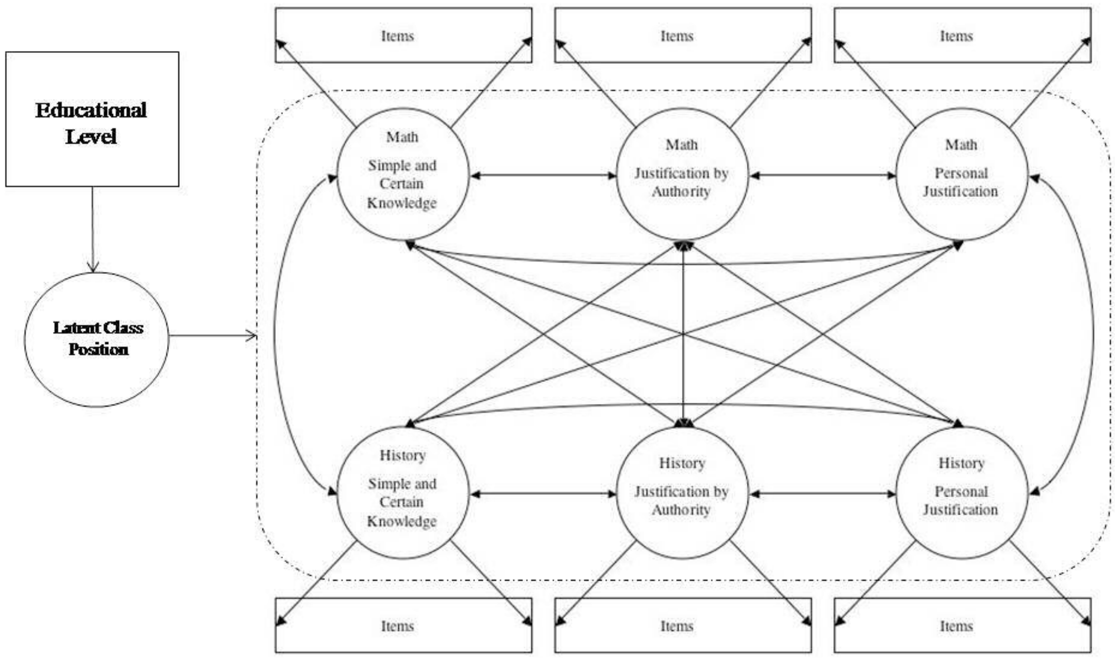
Educational Level Hypothesis

Hypothesis five stated that graduate students would be more likely to be in a higher position for both math and history than undergraduates, who were predicted to be higher than high-school students, who in turn were predicted to be higher than middle-school students. To test this, the latent class variable was regressed on a covariate of educational level (middle-school, high-school, college freshmen, sophomore, junior, senior, and graduate student). In Mplus, models with a categorical outcome variable (in this case math and history position) are estimated using a logistic regression model.

The final factor mixture model with the covariate is shown in Figure 4.

Figure 4

Final Factor Mixture Model with Covariate



Research Questions and Hypotheses

The research question and associated hypotheses were as follows.

Research Question: What evidence is there supporting or refuting the EOCDM based on the construct and discriminant validity and reliability of scores from the EOCQ?

Hypothesis 1: The statistical measurement model, which allows all latent factors (simple and certain knowledge, justification by authority, and personal justification dimensions) to covary, will have an acceptable level of data-model fit according to Hu and Bentler's (1999) criteria.

Hypothesis 1a: The construct reliability of latent factor scores derived from the measurement model will have a Coefficient *H* value greater than or equal to .7.

Hypothesis 2: Domain-specificity will be found, with items for history and mathematics loading on separate latent factors.

Hypothesis 3: The hypothesized factor mixture statistical models will have an acceptable level of data-model fit. The fit of these statistical models will be compared to alternative factor mixture statistical models positing more positions, as well as ones positing fewer positions, as well as models with less restrictive assumptions. Procedures and criteria for factor mixture model fit as outlined by Lubke and Muthén (2005) will be used.

Hypothesis 3a: The construct reliability of latent factor scores derived from the factor mixture model will have a Coefficient *H* value greater than or equal to .7.

Hypothesis 4: For a majority of individuals, their conceptual model-predicted EOCDM position within history will be equal to or higher than their conceptual model-predicted position for mathematics.

Hypothesis 5: Educational level and EOCDM positions in history and mathematics will be probabilistically related, with higher levels of education predictive of higher positions within the EOCDM.

Hypothesis 1: Measurement Model Results

The measurement model (see Figure 2) was assessed to determine whether the individual items were valid indicators of their respective factors. The measurement model included covariances between all factors and error covariances between parallel items for math and history (e.g. Items 1 and 14 in Appendix E). The model was fit using Mplus 4.2 (Muthén & Muthén, 2006) with a robust estimator to account for multivariate non-normality in the indicators. Descriptive statistics for the individual items are listed in Appendix G. Numerous fit indices and tests were examined, but Hu and Bentler's (1999) criteria were used as the main arbiter of model fit. These criteria state that models should have an SRMR less than .09 and either a CFI greater than or equal to .96 or an RMSEA less than or equal to .06, although these values were not derived using a robust estimator. Model fit indices, including which have been computed using robust estimation, and statistics are listed in Table 17.

Table 17

Measurement Model Fit Indices and Statistics

Fit index/statistic	Recommended value[a]	Measurement Model Value
Robust Chi-square	$p > .05$	906.917, 271 *df* ($p < .001$)
Robust Chi-square/df ratio	< 2.0	3.35
Robust Comparative Fit Index	≥ .96	.860
Robust Tucker-Lewis Coefficient	≥ .96	.832
Standardized Root Mean-Square Residual	< .09	.077
Robust Root Mean Square Error of Approximation	≤ .06	.060

[a] Recommended values based upon Kline (2005) and Hu and Bentler (1999).

It should be noted that Hu and Bentler's CFI and RMSEA criteria were not determined using robust estimation; further, regarding the CFI specifically, recent research has suggested that it may degrade in models containing a large number of variables such as this one (Kenny & McCoach, 2003). Solely judging model-data fit by the statistical significance of the chi-square and the CFI and TLI, the fit is not acceptable. However, using Hu and Bentler's (1999) criteria, given that the SRMR and RMSEA are within the recommended values, there is evidence to retain the hypothesis of adequate data-model fit of the measurement model. The standardized factor loadings are listed in Table 18.

Table 18

Measurement Model Standardized Factor Loadings

Math Factors			History Factors		
Simple/Certain Knowledge (Items 1-5)	Justification By Authority (Items 6-9)	Personal Justification (Items 10-13)	Simple/Certain Knowledge (Items 14-18)	Justification By Authority (Items 19-22)	Personal Justification (Items 23-26)
-.556**	.672**	.736**	-.464**	.756**	.659**
.077	.665**	.316**	.329**	.789**	.052
.377*	.767**	.807**	.678**	.852**	.617**
.275*	.758**	-.453**	.637**	.855**	-.664**
-.120*			-.309**		

* $p < .05$
** $p < .01$

Items written to have negative loadings on factors (items 1, 5, 13, 14, 18, and 26) did indeed load negatively. As can be seen in Table 18, all but two indicators were statistically significant at the .05 level or lower. In addition, all but four indicators had factor loadings equal to or greater than .3, a standard for acceptable loadings in exploratory factor analysis (DeVellis, 2003; Gorsuch, 1983) but certainly a weak standard for CFA. From these results, it appears that the simple and certain knowledge in math factor was most problematic. It had one statistically non-significant loading and three loadings below .3. Table 19 lists the error covariances in a standardized metric as correlations, with all but two being statistically significant, implying relevant method covariance between parallel items.

Table 19

Measurement Model Error Correlations

Factor / Items	Error Covariance
Simple and Certain Knowledge Items	
Question 1 and Question 14	.100*
Question 2 and Question 15	.210**
Question 3 and Question 16	.132**
Question 4 and Question 17	.163**
Question 5 and Question 18	.287**
Justification by Authority Items	
Question 6 and Question 19	.064*
Question 7 and Question 20	.076**
Question 8 and Question 21	.0221
Question 9 and Question 22	.064*
Personal Justification Items	
Question 10 and Question 23	.010
Question 11 and Question 24	.183**
Question 12 and Question 25	.133**
Question 13 and Question 26	.175**

* $p < .05$
** $p < .01$

All error covariances hypothesized *a priori* were retained in the measurement model to test their statistical significance in the classes defined by the factor mixture models to follow. Factor correlations, construct reliability, and variance extracted values are listed in Table 20. These values further indicate that the simple and certain knowledge math factor was the weakest using construct reliability and variance extracted as metrics, whereas the justification by authority factors were the strongest.

Table 20

Final Measurement Model Correlations, Construct Reliability (H), and Variance Extracted

	Math Simple/ Certain Knowledge	Math Justification By Authority	Math Personal Justification	History Simple/ Certain Knowledge	History Justification By Authority	History Personal Justification
Math Simple/ Certain Knowledge	.42	.486**	-.914**	-.069	-.033	.204*
Math Justification By Authority		.81	-.180*	.228**	.554**	-.106
Math Personal Justification			.77	.104	.100	-.104
History Simple/ Certain Knowledge				.67	.659**	-.786**
History Justification By Authority					.89	-.549**
History Personal Justification						.68
Variance Extracted	.11	.51	.37	.26	.66	.31

* $p < .05$
* $p < .01$
Note: Construct reliability estimates (H) on diagonal.

The variance extracted was highest for the justification by authority factors, with little variance extracted from the simple and certain knowledge in math factor.

Hypothesis 1a: Reliability Results

The construct reliabilities (see Table 20) of three of the factors were above .7, with two above .67 and with the simple and certain knowledge in math factor having a poor construct reliability of .42. Thus for three of the six factors, hypothesis three was retained, but for the other three it was not. Ultimately, however, the construct reliability must be reexamined in the factor mixture model. In addition, it is important to note that these are reliability estimates based upon this sample and would require confidence intervals to give a sense of plausible population values.

Hypothesis 2: Domain-Generality Versus Specificity Results

Hypothesis two concerned whether the three dimensions, simple and certain knowledge, justification by authority, and personal justification, were domain-general or domain-specific. I hypothesized that a domain-specific model, with separate factors for math and history, would be a better fit than models with domain-general factors. This hypothesis was tested by comparing the fit of the measurement model to the fit of three comparison models. Comparison model one had all of the simple and certain knowledge items loading on the same factor. Comparison model two did the same for justification by authority items and comparison model three did this for personal justification items.

These three comparison models were nested within the measurement model, therefore while the fit indices could be compared, a scaled chi-square difference test provided the most direct evidence as to whether a domain-general factor was supported. Given that these models used a robust estimator, it was necessary to use the scaled chi-square difference statistic (Satorra & Bentler, 1999). If this test was statistically significant, then the comparison model did a statistically significantly worse job of explaining the data, and the measurement model, with domain-specific factors, should be retained. As can be seen in Table 21, each comparison model had poorer results than the measurement model on all model fit indices and had a statistically significant scaled chi-square difference test, supporting the hypothesis that all three factors were in fact domain-specific in this study.

Table 21

Fit Indices and Statistical Tests of Measurement Versus Comparison Models

Model	CFI	TLI	SRMR	RMSEA	χ^2/ *df*	Scaled χ^2 Difference Test
Measurement Model	.860	.832	.077	.060	906.917 / 271	-
Comparison Model One	.807	.773	.092	.069	1149.845 / 276	scaled $\chi^2_{\text{diff}}(5)$ = 195.6887, $p < .001$
Comparison Model Two	.739	.693	.096	.080	1458.193 / 276	scaled $\chi^2_{\text{diff}}(5)$ = 338.6632, $p < .001$
Comparison Model Three	.780	.741	.097	.074	1274.643 / 276	scaled $\chi^2_{\text{diff}}(5)$ = 404.0057, $p < .001$

Hypothesis 3: Factor Mixture Model Results

Initial Estimation Problems

Convergence of mixture models in general can be a difficult issue (McLachlan & Peel, 2000), and this is even more of a problem for factor mixture models. A majority of the hypothesized factor mixture models would not converge with the measurement model described in hypothesis one, even after trying various techniques to achieve convergence such as using different starting values for parameter estimates. As a next step, various items were removed, starting with those that did not have statistically significant factor loadings, items 2 and 24. These items' factor loadings were .077 and .052, respectively. This model also had convergence problems, leading to the decision to remove item 5, which had a statistically significant factor loading below .3. This model also failed to converge. Modification indices for the full measurement model indicated that item 1, which had a statistically significant factor loading of -.556, had strong cross-loadings with other factors, including both math justification factors as well as the justification by authority history factor. The removal of item 1 did produce a factor mixture model that could converge and be estimated. Therefore, the analysis required removing a total of four items, which included the following, "In math, the truth means different things to different people," "To know math well, you need to memorize what you are taught," "Math is so complex that humans will never really understand it," and "In history, if you believe something is a fact, no one can prove to you that you are wrong." Each of the removed items were set aside for further analysis in the future. The removal of these items also necessitated the removal of their associated error covariances from the model.

A confirmatory factor analysis of this reduced model, using a robust estimator, with four factor indicators removed, produced more favorable fit indices and reliability estimates than the original measurement model, and similar factor loadings (see Tables 22, 23 and 24).

Table 22

Measurement and Reduced Measurement Model CFA Fit Indices and Statistics

Fit index/statistic	Recommended value[a]	Original Measurement Model	Reduced Measurement Model Value
Robust Chi-square	$p > .05$	906.917, 271 *df* ($p < .001$)	580.625, 185 *df* ($p < .001$)
Robust Chi-square/df ratio	<2.0	3.35	3.14
Robust Comparative Fit Index	≥.96	.860	.903
Robust Tucker-Lewis Coefficient	≥.96	.832	.879
Standardized Root Mean-Square Residual	<.09	.077	.064
Robust Root Mean Square Error of Approximation	≤.06	.060	.057

[a] Recommended values based upon Kline (2005) and Hu and Bentler (1999).

Table 23

Reduced Measurement Model CFA Model Factor Loadings

Math Factors			History Factors		
Simple/Certain Knowledge (Items 3-4)	Justification By Authority (Items 6-9)	Personal Justification (Items 10-13)	Simple/Certain Knowledge (Items 14-18)	Justification By Authority (Items 19-22)	Personal Justification (Items 23, 25, 26)
.724*	.670*	.710*	-.444*	.755*	.645*
.545*	.669*	.347*	.362*	.791*	.607*
	.771*	.841*	.689*	.853*	-.678*
	.752*	-.437*	.647*	.854*	
			-.314*		

* $p < .01$

All of the factor loadings of the reduced model were statistically significant, with none below .3.

Table 24

Reduced Measurement Model Correlations, Construct Reliability (H), and Variance Extracted

	Math Simple/ Certain Knowledge	Math Justification By Authority	Math Personal Justification	History Simple/ Certain Knowledge	History Justification By Authority	History Personal Justification
Math Simple/ Certain Knowledge	.60	.337**	-.315**	-.143*	.116*	-.003
Math Justification By Authority		.81	-.144*	.222*	.400**	-.074*
Math Personal Justification			.79	.125*	.100*	-.101
History Simple/ Certain Knowledge				.68	.619**	-.672**
History Justification By Authority					.89	-.396**
History Personal Justification						.68
Variance Extracted	.41	.51	.38	.26	.66	.41

* $p < .05$
* $p < .01$
Note: Construct reliability estimates (H) on diagonal.

The construct reliability of the simple and certain knowledge factor, which was most problematic in the original measurement model, increased to .60, and the variance extracted for this factor also increased to .41. The construct reliability of the history personal justification factor, which was the other factor that had an item removed from it, stayed at .68, with an increase in variance extracted to .41. Therefore, given the feasibility, improved fit, and construct reliability of factor scores of this reduced model, it was used as the measurement model for each of the subsequent factor mixture models tested.

Factor Mixture Model Testing

Robust estimators are not available for factor mixture model testing, thus adjustments were not made for non-normality in indicators. All factor mixture models tested allowed factor variances and covariances to vary across classes. Lubke and Muthén (2007) have found that the inclusion of covariates in model estimation can facilitate class separation and participant categorization, therefore each model had the latent class variable regressed on the covariate, educational level. The first set of models, called the strict invariance set, had factor loadings, intercepts, and error variances and covariances fixed across classes. The second set of models, called the strong invariance set, had the same restrictions except they allowed error variances and covariances to vary across classes.

For both the strict and strong invariance sets, two, three, and four class factor mixture models were run. In both sets, the four class models did not terminate normally and had solutions with numerous problems including correlations between factors greater than one and negative factor variances. This suggests that the solutions were not valid and therefore they are not reported. All other models converged to admissible solutions using user-provided start values. Mplus 4.2 (Muthén & Muthén, 2006) provides an option of randomly perturbing start values, to determine whether the solution with lowest loglikelihood is repeated. Ideally, this solution should be repeated using different sets of start values to ensure that it is indeed the best estimation of the model. Using this option, each model's lowest loglikelihood was obtained using the unperturbed start values, but it was not repeated using perturbed start values, even with 30 random starts. It appeared that these models were very sensitive to start values.

Better fitting models have log-likelihood, AIC, BIC, and SABIC values closer to zero. LMR and bLRT values less than .05 indicate that a model with at least as many classes as posited is warranted. The LMR and bLRT values are comparisons between models with the same factorial invariance standards, either strong or strict, but different numbers of classes. The preponderance of evidence across each of these metrics suggested that the three class factor mixture model with strong factorial invariance was the best fit (see Table 25).

Table 25

Factor Mixture Model Fit Indices

Model	Log-Likelihood	AIC	BIC	SABIC	LMR	bLRT[a]
Measurement Model	-22584.179	45356.358	45778.913	45480.460	-	-
2 class, strict invariance	-21381.266	43000.532	43535.468	43157.639	.000	.000
3 class, strict invariance	-21247.982	42791.964	43457.263	42987.358	.12	.000
2 class, strong invariance	-21133.144	42566.287	43240.577	42764.321	.000	.000
3 class, strong invariance	-20878.567	42177.133	43121.139	42454.381	.186	.000

[a] bLRT values indicate a comparison between that model and a model with one less class but the same restrictions regarding factorial invariance.

The only metric that did not support the three class strong invariance model was the LMR, which has been criticized as being less accurate than the bLRT (Nylund & colleagues, under review). The bLRT results did suggest that at least a three class strong invariance model was supported. Therefore, using the decision rule for this dissertation, the three class, strong invariance model was chosen as the final factor mixture model for this analysis.

This final factor mixture model had factor loadings different than the reduced measurement model CFA, as can be expected in this type of analysis (see Table 25). The differences in the standardized factor loadings between the reduced measurement model (see Table 23) and the factor mixture model can be attributed to the fact that when there are mean differences in the items across unidentified classes, as can be the case in a single class measurement model, the covariances between those items can be attenuated. The factor mixture model accounts for these mean differences in the items between classes, causing the covariances to differ. In addition, while the unstandardized factor loadings were fixed across classes to meet one of the requirements of strong factorial invariance, the factor and error variances were allowed to vary across classes, resulting in standardized factor loadings that differed across classes (see Table 26).

Table 26

Factor Mixture Model Standardized Factor Loadings

Math Factors			History Factors		
Simple/Certain Knowledge (Items 3-4)	Justification By Authority (Items 6-9)	Personal Justification (Items 10-13)	Simple/Certain Knowledge (Items 14-18)	Justification By Authority (Items 19-22)	Personal Justification (Items 23, 25, 26)
.721, .872, .670	.601, .709, .604	.743, .829, .655	-.499, -.643, -.183	.685, .760, .709	.577, .788, .556
.569, .553, .358	.583, .743, .682	.382, .383, .286	.313, .344, .187	.721, .812, .776	.527, .761, .513
	.671, .837, .738	.832, .832, .751	.613, .707, .379	.783, .829, .851	-.574, -.846, -.537
	.643, .868, .816	-.442, -.454, -.458	.628, .686, .262	.764, .830, .845	
			-.311, -.386, -.173		

Note: All factor loadings $p < .01$. For each set, factor loadings are listed in order for latent class 1, latent class 2, and latent class 3.

Factor correlations, variances, construct reliability, and variance extracted for the factors by class are reported in Table 27.

Table 27

Factor Mixture Model Factor Correlations, Variances, Construct Reliability (H), and Variance Extracted by Class

	Math Simple/ Certain Knowledge	Math Justification By Authority	Math Personal Justification	History Simple/ Certain Knowledge	History Justification By Authority	History Personal Justification
Math Simple/ Certain Knowledge	1.142, .567, .384	.397**, .397**, .471**	-.280*, -.466**, -.563**	.156, -.101, .057	.006, .042, .342*	-.057, .076, .202
Math Justification By Authority		.769, .482, .359	-.178, -.609**, .006	.110, -.048, .509	.430**, .317, .829**	-.005, .093, -.146
Math Personal Justification			1.375, .617, 1.024	.194, .138, -.560	.074, -.134, .106	.009, -.116, -.019
History Simple/ Certain Knowledge				1.037, .898, .195[a]	.565**, .600**, .652*	-.755**, -.880**, -.885**
History Justification By Authority					.809, .497, .353	-.447**, -.528*, -.366*
History Personal Justification						.543, .570, .534
Coefficient *H*	.61, .78, .49	.72, .88, .82	.80, .83, .71	.64, .74, .26	.83, .89, .88	.59, .85, .55
Variance Extracted	.42, .53, .29	.39, .62, .51	.40, .43, .32	.24, .33, .06	.55, .65, .64	.31, .63, .29

* $p < .05$
** $p < .01$
[a] All factor variances except this one have $p < .05$
Notes: Factor variances on diagonal. Multiple values appear in a cell, indicating the value for each class, in order: Class 1, Class 2, Class 3.

From Table 27 it appears that the low variance of the history simple and certain knowledge factor in class 3 had a detrimental effect upon that factor's construct reliability and variance extracted. In general, the factors in class 3 had much smaller variances than their respective factors in classes 2 and 3, affecting the standardized factor loadings that are used to determine both Coefficient *H* and the percentage of variance extracted. This explains the lower values for class 3 on these metrics.

Hypothesis 3a: Factor Mixture Model Construct Reliability Results

The construct reliability results for the factor mixture model are difficult to interpret because they vary by class. In general, 12 of the 18 construct reliability values were above .7. In absolute terms, classes 1 and 3 each had three factors each with construct reliabilities above .7, whereas in class 2 all construct reliabilities were above .7. The construct reliability of the factors in class 2 were all higher than those in the reduced measurement model, while those in class 3 were lower, with class 1 having some construct reliabilities higher and some lower. Again, the dependency of Coefficient *H* upon factor variances may explain the differences in construct reliability of factors across classes.

Interpretation of Factor Mixture Model Classes

The next question concerned the interpretation of the latent factor means within each class to determine whether the hypothesized EOCDM positions were supported (see Table 7). Estimation of a factor mixture model includes a latent class cluster analysis where participants are grouped based upon how similar they are in terms of their theoretical latent factor scores. Participants are given a likelihood of being in each class, and then assigned to the class for which they have the highest likelihood. Classification of participants based upon their most likely latent class membership using this final factor mixture model resulted in 248 participants in class one, 221 in class two, and 193 in class three. Each class, then, has a latent factor mean for each dimension based upon the average of theoretical latent factor scores for all participants in that class. Factor means are measured on a latent scale, thus the means in one class must be set to zero to establish reference points (Kline, 2005). In this model, the means of the third class were set to zero. Latent factor means for all classes are shown in Table 28. Each latent factor was measured on its own unique scale, thus it is not appropriate to compare latent factor means across factors. The means are not on a standardized metric because the factor variances differed greatly, calling into question whether an appropriate pooled variance could be computed for standardization purposes.

Table 28

Latent Class Factor Means

Class	Math Simple/ Certain Knowledge	Math Justification By Authority	Math Personal Justification	History Simple/ Certain Knowledge	History Justification By Authority	History Personal Justification
1	-.549*	-.923*	-.254	-1.117*	-1.035*	.538*
2	-.146	-.438*	-.496	-1.175*	-1.058*	.875*
3	0	0	0	0	0	0

* Statistical test of this mean compared to class three mean of 0 had $p < .05$

In Table 28, statistical significance indicates that the latent factor mean differs statistically significantly from zero, the factor mean for class three. The factor means for math justification by authority in classes one and two also differ statistically significantly from each other. Each of the history factor means in classes one and two differ statistically significantly from zero, but not from each other. Within each dimension and across classes, the means can be categorized as either low, mid, or high. These classifications can then be used to categorize the classes according to EOCDM position (see Table 8). Interpretations of the factor mixture model latent factor means in terms of the EOCDM positions are shown in Table 29.

Table 29

Interpretation of Latent Class Factor Means

Class	Math Simple/ Certain Knowledge	Math Justification By Authority	Math Personal Justification	History Simple/ Certain Knowledge	History Justification By Authority	History Personal Justification
1	Low	Low	High	Low	Low	High
2	High	Mid	High	Low	Low	High
3	High	High	High	High	High	Low

For example, the math simple and certain knowledge latent factor mean for class one was statistically significantly lower than the means for classes two and three, whose means did not statistically significantly differ from each other (see Table 28). Therefore, it can be interpreted that class one's math simple and certain knowledge mean was low, whereas the other two classes' means were high (see Table 29). Likewise, in math justification by authority, all three latent class means differed statistically significantly from each other, suggesting the class one's mean be considered low, class two's mid, and class three's as high. By examining each class's pattern of means within the math and history factors, classes can be categorized as realist, dogmatist, skeptic, or rationalist (see Table 7).

Characterizing these classes in terms of positions (see Table 30) suggests that participants placed in class one can be considered skeptics (e.g. low simple and certain knowledge, low justification by authority, high personal justification) in both math and history. On average, these participants believed that knowledge was not simple and certain, and also had little faith in authority figure's ability to provide justification. Instead, these participants believed that "facts" in math and history were really just opinions and that there were few "right" answers. The class two math position is somewhat ambiguous with the justification by authority value being mid, but overall suggests a realist position for math and a clear skeptic position for history. These students responded similarly to class one respondents in terms of history, but had a less adaptive view regarding math, thinking that knowledge was simple and certain, with personal experience held in high regard and authority figures somewhat less so. The math position for class three is clearly realist, but the history position is less clear with a high value for simple and certain knowledge but a low value for the personal justification factor. This pattern of means was not hypothesized, and seems to be a mix of the realist and dogmatist positions. In terms of their history position, these participants claimed knowledge was simple and certain, but denied that personal opinion was a sufficient means of justification. This was an unexpected result because according to the EOCDM a belief in simple knowledge should result in the acceptance of any means of justification, either authority or personal experience.

Table 30

Latent Class EOCDM Positions

Class	Math Position	History Position
1	Skeptic	Skeptic
2	Realist[a]	Skeptic
3	Realist	Realist/Dogmatist[a]

[a] Interpretation does not strictly follow from EOCDM

Therefore, of the six latent class positions, four align with the hypotheses generated by the EOCDM, whereas two do not. This can be considered mixed support for retaining hypothesis 3.

Hypothesis 4: Math and History Positions Results

Hypothesis four stated that participants' history position should be at least as high as their math position. An examination of the three latent classes from the factor mixture model shows evidence supporting this hypothesis. Given that the skeptic position is more adaptive than the realist, in each class the history position is at least as adaptive as the math position (see Table 30). The history position in class three is somewhat difficult to interpret, but is certainly at least as adaptive as the math position, supporting hypothesis four.

Hypothesis 5: Educational Level and Math and History Positions

The last hypothesis concerned whether there was a relationship between educational level and EOCDM position. The statistical test of this hypothesis involved a logistic regression of the latent class variable on educational level. Before this is examined, however, it is helpful to examine frequency data.

In the results of the factor mixture model, each participant was given a posterior probability of being in each of the three classes. Using each participant's most likely class, Table 31 shows the frequency of each class by educational level.

Table 31

Frequency of Each Latent Class by Educational Level

Educational Level	Class 1: Skeptic / Skeptic	Class 2: Realist / Skeptic	Class 3: Realist / Realist/Dogmatist	Total
Middle-school	41	1	85	127
High-school	84	42	47	173
Freshman	21	22	13	56
Sophomore	17	26	14	57
Junior	38	48	16	102
Senior	26	51	12	89
Graduate	21	31	6	58
Total	248	221	193	662

In general, middle-school students were more prevalent in the less adaptive class 3, whereas the other educational levels were more likely to be in the more adaptive classes 1 or 2. According to the EOCDM, class 2 is somewhat less adaptive than class 1, making the predominance of college seniors and graduate students in this class an unexpected result. These frequencies can be more thoroughly examined by regressing latent class membership on the covariate, educational level.

The latent variable representing participants' positions in math and history was categorical; therefore using educational level to predict these positions required a logistic regression model. The results of this logistic regression are shown in Table 32.

Table 32

Multinomial Logistic Regression of Position Variable on Educational Level

Comparison	Intercept	b	e^b
Class 1 versus Class 3	-1.376	.149	1.161
Class 2 versus Class 3	-4.918*	.404*	1.498*
Class 1 versus Class 2	3.542*	-.255*	.775*

* $p < .01$

Educational level was coded as a continuous variable representing years in school. As such, middle-school was coded as 6, high-school as 11, freshman as 13, sophomore as 14, junior as 15, senior as 16, and graduate school as 17. The results indicate that for a one unit increase in educational level, an increase of one school year, the odds of being in class one versus class three increased by 16 percent, but that this increase was not statistically significant. It is, however, in the predicted direction as the class one positions in math and history were both skeptic, a more adaptive position than the positions in class one, which were both realist. A unit increase in educational level was associated with a 50 percent increase in the odds of being in class two versus class three, and this difference was statistically significant and in the hypothesized direction, given that class two had a more adaptive position for history than class three. Finally, a unit increase in educational level was also associated with a 22 percent decrease in the odds of being in class one versus class two. This provides further evidence that as educational level increases participants are more likely to be in class two rather than classes one or three.

This result was not hypothesized, given that class one had a more adaptive position in math than class two.

CHAPTER 6: DISCUSSION

In this dissertation, I outlined a new epistemic and ontologic cognitive development model (EOCDM). This model followed in the tradition of personal epistemology research within educational psychology, but was informed by philosophical epistemology as well as developmental psychological work in the area of theory of mind. By incorporating a greater focus upon justification, a main concern of philosophical epistemology, my model accommodated disparate findings from the two psychological literatures as well as informed the measurement of epistemic and ontologic cognition. The conceptual debate within personal epistemology literature regarding domain-generality or specificity was addressed using philosophical literature, and I showed that a domain-specific model, distinguishing between well and ill-structured domains, was the most likely representation of individuals' epistemic and ontologic cognition. I also used philosophical literature to support reclassifying certain aspects of personal epistemology models as ontological, as opposed to epistemological. The integration of personal epistemology, philosophical epistemology, and theory of mind research allowed me to create a model that described epistemic and ontologic cognition throughout the lifespan. In addition, my conceptually grounded model, with domain-specificity and a focus upon justification, allowed for the creation of a more psychometrically sound measure of epistemic and ontologic cognition.

The Epistemic and Ontologic Cognition Questionnaire (EOCQ) was designed to measure the constructs outlined in the EOCDM, and a revision of it was informed by a pilot study and research regarding how individuals view issues of fact versus opinion (Alexander & Dochy, 1995). A revised EOCQ was given to 662 participants who ranged from middle-school to graduate school students. Support for the reliability and validity of scores from the EOCQ was interpreted as initial evidence for retaining the EOCDM as a plausible model of epistemic and ontologic cognition. The EOCDM itself must be tested numerous times and ways over the course of many years before it can be considered a fully defensible model of epistemic and ontologic cognition, however. Nonetheless, the validity of both the conceptual model and the measure were each reciprocally supported by the other.

Within the limitations of this study, the results of this dissertation provided reasonable support for the validity and reliability of scores on the EOCQ with these participants. The hypothesis of domain-specificity was supported, although the degree of this specificity will need to be examined in future studies. Statistical findings were generally supportive of the EOCDM, but the evidence for two of the four positions, dogmatist and rationalist, was mixed. Educational level was related to EOCDM position, with higher educational levels associated with more adaptive epistemic and ontologic cognition positions. The unexpected findings concerning certain EOCDM positions and their developmental progression may have been due to a failure to obtain sufficient numbers of participants in late college and graduate school, some selection bias due to the low response rate among middle-school students, and problems with some of the EOCQ items themselves, such as items 1, 2, 5, and 24. Each of the findings is more completely discussed next, along with the limitations, contributions and implied future directions of this research area.

Discussion of Hypothesis 1

Beyond providing a strong conceptual and theoretical foundation, an important step toward establishing the EOCDM as a viable alternative to other models of personal epistemology was to determine whether an instrument could be developed that measured its underlying constructs. The first hypothesis of this dissertation was that the EOCQ would have acceptable data-model fit according to Hu and Bentler's (1999) criteria, and this hypothesis was retained. This provided support for the construct validity of the scores from the EOCQ, and by extension, provided some evidence suggesting that the underlying EOCDM may be an accurate representation of epistemic and ontologic cognition. Work in both personal epistemology research (Hofer, 2004b; King & Kitchener, 2004; Kuhn & Weinstock, 2002) and philosophical epistemology (Williams, 2001) suggests the predominance of justification in epistemic cognition. The EOCQ's inclusion of two separate justification factors, one for authority and another for skepticism, allowed for a more nuanced measurement of how individuals go about establishing justification for knowledge than other models that posit only a single justification factor comprising both authority and skepticism (e.g. Hofer, 2004). Measurement model results supported capturing justification using multiple factors. Indeed, Kuhn's (2005) and King and Kitchener's (2004) exploration of adults' standards of justification suggests that there may be even more ways that individuals think about justification, beyond just faith in authority or skepticism.

However, other measures of data-model fit, and by extension the construct validity of scores from the EOCQ, were less clearly supportive of the model, including the CFI, TLI, and chi-square. The chi-square value was statistically significant, implying that there still existed some degree of misfit in the measure. The chi-square test has as its null-hypothesis that the model implied relations between variables and the actual data-derived relations are statistically equivalent. Thus, a rejection of the null-hypothesis suggests that the model is not an accurate representation of the data. The chi-square has been championed by some as the only important metric of data-model fit (Hayduk & Glaser, 2000) and indeed a statistically non-significant chi-square value is the gold standard for latent variable models in general. The statistically significant chi-square result for this analysis suggests that the EOCQ can be improved as a measure of epistemic and ontologic cognition.

Other indications of data-model fit include the 26 factor loadings, of which all 26 were in the hypothesized direction, 24 were statistically significant and 22 were above .3. Certainly this is encouraging regarding the degree to which the items capture the underlying constructs, but in general it would have been more desirable to have items with standardized factor loadings higher than .3, with each statistically significant. The small factor loadings contributed greatly to the rather low variance extracted values for the math and history simple and certain knowledge and personal justification factors. The construct reliability of these factors was also below the hypothesized .7 metric. In all, these problems all indicated that while the EOCQ could be used for analyses in this dissertation, for future work it will be important to refine the items to improve its psychometric qualities. The strongest case for the EOCDM would be an EOCQ with a statistically non-significant chi-square and strong, statistically significant factor loadings allowing for each factor to have a variance extracted percentage above .5 (Gorsuch, 1983), and a construct reliability above .7 (Cronbach & Shavelson, 2004). Indeed, the fact that the EOCQ did not achieve these standards may be the reason why the factor mixture model was difficult to estimate, a problem discussed later. However, constructs in the factor mixture model often had higher maximal reliabilities and variance extracted than those in the measurement model, a positive aspect of the factor mixture model that must be considered as well when evaluating the EOCQ and EOCDM. This is also discussed later.

It should be noted that the EOCQ had stronger evidence of its psychometric quality than previous measures including the EQ (Schommer, 1990) or the EBI (Schraw et al., 2002). The EOCQ did achieve acceptable CFA fit using Hu and Bentler's (1999) standards, something that cannot be claimed about the EQ. The EBI has only been tested using a CFA once (Greene et al., 2006) with acceptable but poorer data-model fit, variance extracted, and construct reliability results than the EOCQ, as reported here.

Discussion of Hypothesis 2

In addition to the concerns regarding the lack of construct validity evidence for previous measures of personal epistemology (Clarebout et al., 2001), there continues to be debate about whether the underlying constructs are domain-general or specific (Buehl & Alexander, 2001, 2005; Buehl, Alexander, & Murphy, 2002; King & Kitchener, 2004; Pintrich, 2002; Schommer & Walker, 1995). Lately, a consensus has begun forming around the idea that there are both domain-general and specific aspects of epistemological beliefs (Buehl & Alexander, 2005; Hofer, 2002).

My EOCDM was based upon a theoretical and philosophical argument that complete domain-generality is a form of vulgar relativism, a stance highly unlikely, if not impossible to hold. Instead, I suggested that epistemic and ontologic cognition could vary according to whether the domain discussed is well or ill-structured. The EOCQ contained parallel items for math and history within well and ill-structured domains respectively.

The results indicated that a domain-general factor structure was not supported, and that my hypothesis of domain-specificity should be retained. This provided further evidence suggesting that epistemic and ontologic cognition varies across domains. A full test of my hypothesis regarding the degree of specificity, particularly at the well and ill-structured level, will require an EOCQ with items addressing multiple well and ill-structured domains. Nonetheless, these findings aligned with the work of Buehl and colleagues (Buehl & Alexander, 2001, 2005; Buehl, Alexander, & Murphy, 2002) who also used factor analytic techniques to provide empirical support contradicting the strict domain-generality arguments of other theorists.

Discussion of Hypothesis 3

Item Removal Issues

Initial factor mixture model estimation problems prompted the removal of four EOCQ items from this analysis. Three of these items either had statistically non-significant factor loadings, or factor loadings below .3, both indicators of problems with the item itself. The fourth, item one, had strong cross-loadings with multiple factors, suggesting that it also failed to adequately capture its intended dimension and nothing else. Once these items were removed, factor mixture model estimation proceeded normally. While it is certainly not ideal to remove items hypothesized to load on the factors of interest, it is not unusual for new instruments to require revision based upon initial analyses (DeVellis, 2003). These results suggested that these items be revised for future administrations, and indeed better designed items may lead to better data-model fit indices and a statistically non-significant chi-square for the measurement model.

It was not immediately apparent why items two ("To know math well, you need to memorize what you are taught") and 24 ("In history, if you believe something is a fact, no one can prove to you that you are wrong") caused problems in the factor mixture model, particularly given that their parallel items in the other domain did work well. Another think-aloud study may shed light on how participants were interpreting these items.

On the other hand, the use of the word "truth" in item one ("In math, the truth means different things to different people") may have confused respondents. Whereas in history the "truth" is often debated, this term may be less familiar in the context of mathematics. Finally, item five ("Math is so complex that humans will never really understand it") contained two separate ideas, that math is complex and that humans cannot comprehend it. This may have led to students responding to only one of the ideas in the item, and perhaps likewise for its parallel item for history. In the case of mathematics, this extraneous variance may have been strong enough to disrupt the factor mixture model estimation process.

Factor Mixture Model

A three class, strong factorial invariance factor mixture model was chosen as the best fit to these data. This model was supported by model fit indices, including the AIC, BIC, SABIC, and bLRT results, although estimation problems limited my ability to compare the three class model to more complex models with four or more classes. This three class factor mixture model included numerous factors with stronger loadings, higher construct reliability, and more variance extracted than the measurement model discussed in hypothesis one. In all, these results suggested that the construct validity and reliability of the measurement model may have been masked by the latent classes within this sample. The factor mixture model took into account these classes, allowing for better measurement. The psychometric properties of the EOCQ, as measured by the factor mixture model, exceeded the results of Schommer's (1990) EQ and Schraw and colleagues' (2002) EBI, providing further support for its use an alternative to these measures. However, items had to be removed from the math simple and certain knowledge and history personal justification factors to allow the factor mixture model to converge. The removal of these items calls into question whether there was sufficient evidence of construct validity for these two dimensions. In the end, it must be acknowledged that these dimensions most likely have not been captured sufficiently.

In the end, factor mixture models are not useful unless the latent classes of respondents are interpretable based upon the theory driving the analysis. Hypotheses derived from the EOCDM predicted that only certain patterns of latent factor means would be found, and that these patterns could be interpreted as representing one of four positions: realist, dogmatist, skeptic, and rationalist (see Table 7). An examination of the latent factor means in each class (see Table 29) revealed that four of the six patterns of means were clearly interpretable using predictions from the EOCDM. One class was clearly comprised of skeptics in both math and history. These students had lost faith in authority and had adopted the belief that objective truth does not exist in these areas. Another class seemed to be realistic regarding math and was clearly skeptical regarding history. These individuals viewed math as a simple and certain, objective domain where justification merely required presenting evidence from an authority figure or one's own experience, but viewed history as less definitive. The last class contained individuals who were clearly realists in terms of math. The history position was harder to identify, but appeared to be more dogmatic, suggesting that they recognized the complexities of the domain, but felt that authority figures had the ability to "prove" what was "correct."

The analysis of educational level and EOCDM position, discussed later, suggested that the second latent class, which contained the problematic realist in math position, may have been a combination of realists and skeptics in math. In my EOCDM, I predicted that skepticism in math should not occur before mid to late college (see Table 8), and even then only in some individuals. This sample contained 249 juniors, seniors, and graduate students. This was only 38 percent of the sample, and given that movement from realism in math occurs for only a portion of late college and graduate students, there simply may not have been enough math skeptics for the factor mixture model to be able to discriminate them from realists. Factor mixture models often require large numbers of participants to discern latent classes, and it could have been that the low number of skeptics could not be adequately differentiated from the realists in this class.

The problematic interpretation in history, found in class three, mirrored a problem that Hallet and colleagues (2002) had. They reported difficulty in discriminating between realists and dogmatists using their measure, which was a problem for the EOCQ as well. The inclusion of the ontologic cognition factor, simple and certain knowledge, was intended to help facilitate this discrimination, but in these analyses it did not seem to be performing in this way. Again, it may be that there simply were not enough participants who were dogmatists to discern their class using a factor mixture model. It was also disappointing to find no rationalist positions in this analysis. Again, it may be that the relatively small number of college seniors and graduate students did not allow class three to separate into a realist/realist class and more adaptive classes. This is certainly an issue for future research, and more advanced students are needed to test this assertion.

Overall, the analysis using the factor mixture model did support numerous aspects of the EOCDM, in particular the skeptic positions in math and history and the realist position in math. It also demonstrated the importance of considering latent factor mean differences when evaluating the validity and reliability of instruments measuring epistemic and ontologic cognition. The psychometric qualities of the EOCQ, in particular the standardized factor loadings, changed considerably when mean differences between latent classes were considered. This is evidence that mean differences can attenuate relations in the measurement model, obfuscating measures of reliability and validity. Finally, the interpretability of four of the six positions was an encouraging result for an initial administration and analysis.

Discussion of Hypothesis 4

In the EOCDM I posited four positions in a developmental sequence from least to most adaptive: first realist, then dogmatist or skeptic, and lastly rationalist. In terms of relations across well and ill-structured domains, I hypothesized that participants' ill-structured domain position should be at least as adaptive as their well-structured domain position. Despite the limited number of classes extracted from the data, the evidence supported retaining hypothesis four (see Table 30). In each class, the history position was at least as adaptive as the math position, if not more adaptive. For example, in the second class the math position was realist while the history position was a blend of realists and skeptics. Regardless of what the actual classification should be, the history position would be at least as adaptive as the realist math position.

These findings were congruent with work done in developmental psychology, and in particular Chandler and colleagues' (2002) theory of mind model. It also cohered with the work of Perry (1999), King and Kitchener (2004) and Kuhn and Weinstock (2002) who all suggest that epistemic cognition moves from what I would call a more realist position to some kind of skepticism, followed by a version of rationalism. These researchers, in particular Perry and King and Kitchener, claim that the movement from a realist position does not occur until college, a claim I disputed on theoretical, philosophical, and, with these results, now empirical grounds. I also differed with these researchers regarding their claims regarding the domain-generality of epistemic cognition, as my model adhered more with the work of Buehl and colleagues (Buehl & Alexander, 2001, 2005; Buehl, Alexander, & Murphy, 2002) showing a middle ground between domain-general and domain-specific epistemic cognition.

Discussion of Hypothesis 5

The final hypothesis of this dissertation concerned the relation between educational level and EOCDM position in math and history. In the EOCDM, I predicted that cognitive development would be associated with more adaptive positions in both math and history. Due to the lack of an acceptable measure for formal operations, I had to use educational level as a proxy. However, this had many drawbacks, as it was confounded with age and cognitive ability. Future studies should include a better measure of individual cognitive development, rather than classifying all students within a grade similarly.

Despite the less than optimal nature of this proxy, the frequency data of class by educational level also provided evidence supporting the general hypothesis. Middle-school students were predominantly in the less adaptive class, whereas college and graduate students were most likely to be in the more adaptive classes. The results of a logistic regression of latent class on educational level also provided some support for the hypothesis. In general, as educational level increased, so did the likelihood of being in one of the two more adaptive classes. When findings were not statistically significant, they were in the predicted direction. Participants at a higher educational level were statistically significantly more likely to be in the realist/skeptic class than either of the other two (see Table 30). It is possible that the realist/skeptic class could have been a hybrid containing an undifferentiated rationalist/rationalist class, given the mid value for history justification by authority. If this were the case, this could have been the reason for these somewhat contradictory results. A larger sample with more graduate students may help discriminate between these two latent classes.

As stated earlier, many models of personal epistemology claim that more adaptive epistemic cognition does not develop until college. Yet in this study, 42 of the 147 middle-school students displayed some form of epistemic cognition beyond realism, as did 84 of the 173 high-school students. Therefore, my model and the analyses here supported the work in developmental psychology showing that for many students the progression toward more adaptive epistemic and ontologic cognition begins in middle-school, not college.

In summary, the scores on the EOCQ provided initial empirical support for the EOCDM. Certainly much more work needs to be done before the EOCQ can be considered an instrument ready for use in applied situations. Until the psychometric and factor mixture model estimation concerns with the EOCQ are adequately addressed, empirical support for the EOCDM will remain promising but incomplete.

Contributions

Theoretical Contributions

The current unorganized state of personal epistemology research suggested the value of creating a new model of epistemic and ontologic cognition that could integrate the findings and ideas of the other models. My model built upon Perry's (1999) basic structure, as does most of personal epistemology research. But I also incorporated aspects of other models within educational psychology, including King and Kitchener's (2004) ideas regarding whether young children can even engage in epistemic cognition, their focus on justification, and their claims regarding level of educational attainment and epistemic cognition. From Kuhn's (Kuhn & Weinstock, 2002) work I incorporated a focus upon justification, an idea also supported by Hofer (2000). From Buehl and colleagues' (Buehl & Alexander, 2001, 2005; Buehl, Alexander, & Murphy, 2002) work I adopted a stance between domain-generality and specificity that was similar to Chandler and colleagues' (2002). Schommer-Aikins' (2004) model provided the impetus for my simple and certain knowledge factor, and I used aspects of her EQ to inform the creation of my own quantitative instrument. This integration of many models of personal epistemology was something that numerous authors (Hofer, 2004a; Benedixen & Rule, 2004) have suggested. In addition I incorporated philosophical epistemology into the model, something that has also been advocated (Murphy et al., 2007).

Philosophical epistemology focuses upon justification, providing the support for my model's increased attention to this issue. I also utilized philosophical epistemology to resolve concerns regarding which factors should and should not be considered epistemological as well as whether domain-generality was plausible. The EOCDM also incorporated research from developmental psychology and was designed to be able to account for findings in that field as well as those in educational psychology. In particular, the model accounted for findings in developmental psychology showing cognition beyond dualism before the college years, and it also incorporated ideas of dogmatism and skepticism from Chandler and colleagues' (2002) model. Overall, the strong, interdisciplinary foundation for the EOCDM, spanning educational psychology, developmental psychology, and philosophy, allowed for the creation of a quantitative measurement instrument that was more likely to meet high psychometric standards.

My results clearly supported three important conclusions that are contributions to the personal epistemology literature beyond theoretical integration. First, more adaptive epistemic and ontologic cognition begins well before the college years for many students. The idea that high school students think dualistically with complete reverence for authority figures does not align with theory, anecdotal or empirical evidence. Second, there does appear to be some level of domain-specificity to epistemic and ontologic cognition, as evidenced in the work described here and elsewhere. Finally, this dissertation reasserted the importance of more sophisticated conceptual modeling of justification in epistemic cognition. Philosophical epistemology places great importance upon how individuals justify their knowledge. Theory and empirical results support the idea that justification is a complex and multi-faceted construct, and cannot be simplified into a single continuum with belief in authority on one end and vulgar relativism on the other.

Methodological Contributions

This dissertation underscored the importance of developing measures of epistemic and ontologic cognition that meet high standards for psychometric quality. Instruments designed to measure psychological constructs, such as epistemic cognition, must be pilot tested carefully. This study showed how items that appear clear to researchers often are not so to participants. Likewise, examining think aloud data as well as quantitative results can help explain the confusions participants encounter, and point to new ways of measuring the latent factors. Pilot testing helps produce instruments that are more likely to display strong psychometric qualities with their intended populations, including validity and reliability. Construct validity should be tested using confirmatory methods. Also, metrics for validity and reliability should match the analyses performed, for example by using Coefficient *H* for factor reliabilities rather than Cronbach's alpha (Hancock & Mueller, 2001). This dissertation highlighted these more sophisticated techniques that should be used more often in educational psychology studies. The validity and reliability of scores must be tested before they can be used in further analyses or interpretations. Studies may produce results that seem to support the hypotheses, but without testing the validity and reliability of their scores, these findings remain unpersuasive (e.g. Bråten & Stromso, 2005; Schommer-Aikins et al., 2002).

Many of the studies mentioned previously utilized a "two-step" approach, where a CFA was used to obtain factor scores and then various criterion variables were regressed on these scores, with or without other covariates. More powerful and elegant techniques exist, such as including covariates and criterion variables in the CFA or factor mixture model itself, as done in this study. This allows a test of the overall model in its entirety, and can facilitate estimation and data-model fit (Lubke & Muthén, 2005). Also, because all aspects of the conceptual model can be statistically analyzed simultaneously, it allows for a more persuasive argument for the validity of the measure and the value of the model.

In addition, the factor mixture model used in this study illustrated how ignoring potential latent factor mean differences between latent classes can hinder measurement, decreasing the validity of scores taken from instruments. Numerous studies have examined the relations between factor scores and various academic outcomes (Schommer, 1990, 1993) without considering the possibility that unobserved group differences within the sample may be masking relations. At best this practice may fail to disattenuate error that can disguise results, at worst it may render such analyses meaningless, particularly when factor scores are used as predictor variables in statistical models, such as multiple linear regression (Pedhazur, 1997), that include an assumption of accurate measurement of those variables.

However, factor mixture models are also very problematic. They require large sample sizes and depend upon distributional assumptions, such as the normal distribution of indicators and latent factors that may not be tenable in most samples (Bauer & Curran, 2003). The testing of these models is also a relatively new area, and current recommendations include assuming the invariance of factor loadings or intercepts across the latent classes (Lubke & Muthén, 2007). This is of some concern because conceptually factor mixture models are akin to multigroup SEM analyses, except in the former the groups are unknown, whereas in the latter they are known a priori. An important aspect of multigroup SEM is the testing of the invariance of the factor loadings and intercepts across groups (Kline, 2005). Given the similarities between multigroup SEM and factor mixture modeling, it would seem that testing the invariance of factor loadings and intercepts would be important in both kinds of analysis. When invariance is not tenable, it implies that the items measure different things in different groups, an important finding that invalidates comparisons of group means. These group means, called latent class means in a factor mixture model because the groups cannot be directly observed, are used to characterize the classes. Therefore, if the factor loadings or intercepts in a factor mixture model are not invariants, then the means are not valid, invalidating the classifications. Given that the classifications are one of the primary goals of a factor mixture model, it would seem that an examination of the tenability of invariant factor loadings and intercepts should be an essential step in factor mixture modeling, not one that is skipped.

Finally, this study assessed the validity, reliability, and predictive qualities of scores from the EOCQ with a sample that included students from middle-school through graduate school. This allowed cross-sectional comparisons regarding the relative development of students from each educational level, and decreased the chances of range restrictions that may attenuate correlations between variables when studied within a group of students of similar age or educational level. For example, studies of epistemic cognition that only focus on college students may suffer due to the lack of variance within this group. Including a wider range of ages and educational levels ensures better estimation of the variance of each measure, and the covariances between measures.

Implications for Education

While preliminary in its findings, this study has two implications for educators and students. First, teachers should try to recognize the underlying epistemic and ontologic beliefs of their students (Alexander et al., 1998). Whereas other models of personal epistemology (King & Kitchener 2004; Perry, 1999) make this task particularly easy for middle-school and high-school teachers by suggesting all students are some form of dualist, my dissertation illustrated that a far more diverse set of beliefs are possible, even amongst sixth graders. Therefore, it is important for teachers to take into account the epistemic and ontologic cognition of their students. With further revision, the EOCQ may become a relatively quick yet accurate way to ascertain this information. EOCQ results could be used to characterize students as realists, dogmatists, skeptics, or rationalists in various domain areas. However, it is important to consider that response bias is likely to occur when teachers give their students a survey that asks about their faith in that teacher's authority.

Otherwise, assessing students' epistemic and ontologic cognition may require conversations beyond the typical explication of technique or algorithm, and necessitate teachers to probe students' means of justification and understanding of knowledge in a given field. Students who hold a simplistic view of knowledge may be at a real disadvantage compared to their more sophisticated peers, particularly in classrooms where assessment includes more than objectively scored items such as multiple-choice questions. When students are asked to explain their thinking and explore multiple pathways to understanding, those students who have more adaptive beliefs about knowledge and justification will have a head start on those who instead look for the one, simple answer.

Indeed, the failure to account for differences in epistemic cognition may account for some of the difficulties associated with problem-based learning (Kirschner, Sweller, & Clark, 2006). As Sandoval (2005) has illustrated, one reason students do poorly in problem-based or inquiry learning environments is because they fail to adopt more adaptive views regarding the nature of science. Efforts to foster the adoption of more adaptive views are often thwarted because students hold separate formal and practical epistemologies. Formal epistemologies are beliefs about science as it is done by professionals, whereas practical epistemologies are beliefs about how the students themselves seek and justify knowledge. Problem-based learning often fails to take into account these separate sets of beliefs, unintentionally aiming instruction at formal epistemologies and leaves students' practical, and often less adaptive, epistemologies untouched. The students, who often are realists or dogmatists in well-structured domains like science, may then be frustrated by the ill-structured problems, need for learner control, instructions to search for multiple solutions, or subjectivity in evaluation criteria that are typical in problem-based and inquiry learning environments. This frustration may lead to less involvement and poorer performance. These students can be encouraged to challenge their views of knowledge and means of justification by reading refutational texts (Hynd, 2001) and engaging in classroom discussion with their peers as ways to foster development in epistemic and ontologic cognition at the practical level, as Sandoval (2005) describes it. However, whether interaction between peers who differ in their epistemic cognition leads to development in this area remains an empirical question.

The second implication of this study follows from the finding that students' epistemic and ontologic cognition is not domain-general. Therefore, it follows that teachers and parents should not be surprised when students' performance varies from subject to subject. More adaptive epistemic and ontologic cognition in history, for example, might lead to academic performance that is not matched in a science class where the same student's position is realist. Sandoval's (2005) ideas of formal and practical epistemologies imply that even students with a more adaptive position for formal epistemology may hold a less adaptive position in terms of their own, practical epistemology. Teachers should be prepared to assess epistemic and ontologic cognition separately by domain, and understand that gains made in one domain may very well not transfer to others. They may also have to assess whether students' beliefs differ depending upon whether they are seen as relating to professionals or the self.

Limitations

Every study has its limitations, and this dissertation was no exception. Limitations of this dissertation included those regarding the sample and the design.

Sample Limitations

All of the participants for this study were recruited either from a relatively selective mid-Atlantic University or a suburban area of Pennsylvania that is known for its high-quality education systems. As such, the generalizability of the findings was limited by the relative homogeneity of the students. Future studies will be necessary to determine whether these findings are applicable beyond these limited contexts.

Factor mixture models, which include a latent class cluster analysis, require a large number of participants to discriminate classes. The sample size of 662 participants was most likely not sufficient to differentiate the large number of potential latent classes in the EOCDM. In particular, this sample had a relatively small number of college seniors and graduate students, who are most likely to be in the dogmatist and rationalist positions. In this study the dogmatists and rationalists may have been too few in number to adequately discern them from the realists. This may be why evidence for the dogmatist and rationalist positions was somewhat ambiguous.

Design Limitations

The EOCDM was posited to be a developmental model. The cross-sectional design of this study did not allow for true test of developmental progression. Future studies should follow the same students for a number of years to test whether epistemic and ontologic cognition develops in the orderly progression outlined in the EOCDM. A longitudinal study would also allow more opportunities to measure participants' educational exposure and stage of Piagetian cognitive development. Educational level was a poor proxy for these important variables, and it was confounded with age and cognitive ability. More sophisticated and targeted measures are necessary.

While demonstrating domain-specificity of epistemic and ontologic cognition, the EOCQ could not test the degree of this specificity. The hypothesized well versus ill-structured distinction can only be tested using a version of the EOCQ that includes more than one domain from each category. For example, an EOCQ with questions about both math and science could test the well-structured domain hypothesis, while questions about history and literature could test the ill-structured domain hypothesis.

Future Directions

There remains great potential for the EOCDM, but much works needs to be done. Certainly the first concern is improving the EOCQ itself by examining the items that had to be excluded and improving the measurement of the posited factors. Further piloting and discussions with participants regarding their interpretations of these items will help to create an instrument more amenable to the complexity of factor mixture modeling. It is also possible that attitude items cannot capture the ontologic factor. It may be more effective to provide a task asking participants to identify problems as well or ill-structured, with those who are incapable of doing this classified as realists.

Once new items or measures are created, a broader administration with more participants, and particularly more college seniors and graduate students, will be necessary to determine whether the EOCQ, and by extension the EOCDM, accurately captures more adaptive epistemic and ontologic cognition. It has been suggested that the means of justification in adults may be more complex than postulated in many models of personal epistemology (Hofer & Pintrich, 1997), and while the EOCDM does allow for a more nuanced understanding than past models, it too may be underrepresenting the phenomenon. It could be that the means of justification for more sophisticated participants can include ideas beyond authority and the self, to include philosophical epistemology's ideas of coherence or probabilism (Murphy et al., 2007). What is needed is an extended qualitative study of justification with individuals who have more adaptive epistemic and ontologic cognition. While King and Kitchener (2004) and Kuhn (2005) have engaged in qualitative analyses of justification, their work could be informed by the inclusion of concepts from philosophical epistemology, such as coherence as a means of justification (Murphy et al., 2007). Such a study may point toward additional justification factors to be included in measures like the EOCQ.

Another potential addition to the EOCDM, and personal epistemology models in general, is a position of epistemic and ontologic diffusion. As Dr. Patricia A. Alexander has suggested (personal communication, May 11, 2007), it may be that certain individuals have an inconsistent or diffuse set of beliefs about knowledge and knowing, and that their responses do not fit any particular position. It may be that attempts to recncile epistemic and ontologic development is stressful and causes individuals to become stuck between positions, particularly as they encounter experiences and ideas that challenge realist beliefs in a fixed, unchanging, and objective reality. These individuals may respond to the EOCQ in a diffuse manner, with no discernable position. Hammer (1994) has found that students' views regarding the nature of science vary by context, and are not always internally consistent. It would also not be surprising if such individuals' views not only varied by context, but were particularly influenced by the context in which they were given epistemic and ontologic cognition measures. A student who believes in realism in mathematics may be more prone to ignore ontologic doubt about other academic domains when given the survey by a mathematics teacher or in a mathematics classroom, for example.

Indeed, the context in which individuals respond to measures of epistemic and ontologic cognition may even influence those who have fairly strong beliefs about knowledge and knowing. Certainly authoritative teachers may elicit more dogmatic responses whereas environments that promote radical constructivism may influence students to respond in a more skeptic manner. An important question is whether these influences are context-specific and fleeting, or whether they are cumulative, leading to some type of development. Too great a sensitivity to the former would be misleading, while systematically missing the latter would impoverish the conceptual model.

There are numerous potential applications for a fully supportable EOCDM and EOCQ. Hofer (2004) has already posited that individuals' epistemological beliefs may influence their choice of strategies, task definition and degree of metacognitive monitoring. In terms of the EOCDM, I believe that students' positions on the simple and certain factors should influence their task definitions, need for cognition (Cacioppo et al., 2006) and depth of understanding, whereas their positions on the justification continua should influence their metacognitive monitoring. The EOCQ could be used as a predictor of self-regulated learning (SRL) activities (Pintrich, 2000; Winne, 2001; Winne & Hadwin, 1998; Zimmerman, 2000). Azevedo and colleagues (Azevedo & Cromley, 2004; Azevedo, Moos, Greene, Winters, & Cromley, in press; Greene & Azevedo, 2007) have demonstrated how think-aloud protocols can be used to identify the SRL processes students use while engaging in complex tasks. I believe that EOCDM position should be predictive of these processes, with students with more adaptive beliefs more likely to engage in higher-order SRL processes such as planning and monitoring their learning. This research would address *why* students approach learning tasks differently, and help establish the predictive validity of the EOCQ and by extension the utility of the EOCDM and epistemic and ontologic cognition in general. Schommer-Aikins' (2004) ideas regarding embedding epistemic cognition with other important covariates for learning, such as her nature of learning factors, should also be considered. Ultimately, an understanding of the magnitude of the influence of epistemic and ontologic cognition requires examining it simultaneously with other factors known to affect learning.

Finally, it would be particularly interesting to examine teachers' beliefs about the subjects they instruct, and whether congruence between a teacher's and student's positions is associated with more favorable feedback and assessment. It may be that some teachers approach their subjects with a strong epistemic or ontologic position, with students who hold incongruent beliefs being less likely to achieve high grades. The EOCQ would need to be pilot tested with teachers and perhaps altered before such work could be done.

Conclusion

One indicator of a good model is that it is generative, producing new questions and lines for research. The EOCDM does that, with much work needing to be done regarding its measurement and many consequences of its proposed relations awaiting discovery. The model integrates and expands upon the work in personal epistemology to produce a conceptually strong foundation from which psychometrically valid measures of the phenomena can be created. These measures can then be used to explore how students' beliefs about knowledge and its justification both help and hinder the learning process, shedding light on new ways to facilitate their academic performance.

Appendix A: *Pilot Version of the Epistemic and Ontologic Cognition Questionnaire*

The pilot version of the EOCQ that follows is annotated to illustrate which dimension and content area each item assesses. After each item is a code. The dimension is listed first: simple and certain knowledge (SC), justification by authority (JA) and personal justification (PJ). The next part of the code identifies the domain: math (M), history (H), and aesthetics (A). For example, the code SCM indicates an item measuring the dimension of simple and certain knowledge in the area of math. Items that are reverse-coded are indicated with an (RC).

<u>The Epistemic and Ontologic Cognition Questionnaire</u>

For each of the following statements, please answer honestly. There are no "correct" answers. Please circle your answer using a number from the seven-point scale:

1) In physics, the truth means different things to different people (SCMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

2) In math, the truth means different things to different people (SCMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

3) To do well in physics class, the main thing you need to do is memorize facts (SCM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

4) To do well in math class, the main thing you need to do is memorize facts (SCM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

5) In physics, what is true today will be true tomorrow (SCM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

6) In math, what is true today will be true tomorrow (SCM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

7) In physics, the facts do not change (SCM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

8) In math, the facts do not change (SCM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

9) There are some things in physics that we will never understand (SCMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

10) There are some things in math that we will never understand (SCMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

11) If two scientists disagree about some part of physics, one of them must be wrong (SCM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

12) If two mathematicians disagree about some part of math, one of them must be wrong (SCM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

13) If a physicist says something is a fact, I believe it (JAM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

14) If a mathematician says something is a fact, I believe it (JAM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

15) I think the things written in physics textbooks are true (JAM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

16) I think the things written in math textbooks are true (JAM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

17) If my friend and I disagree about something we learned in physics class, we just have to ask the teacher to tell us who is right. (JAM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

18) If my friend and I disagree about something we learned in math class, we just have to ask the teacher to tell us who is right. (JAM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

19) I don't believe everything I learn in physics class. (JAMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

20) I don't believe everything I learn in math class. (JAMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

21) I don't automatically believe whatever my physics teacher tells me. (JAMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

22) I don't automatically believe whatever my math teacher tells me. (JAMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

23) In physics, you just have to decide what you believe and what you do not. (PJM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

24) In math, you just have to decide what you believe and what you do not. (PJM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

25) In physics, if you believe something is true, no one can tell you that you are wrong. (PJM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

26) In math, if you believe something is true, no one can tell you that you are wrong. (PJM)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

27) In physics, the average person cannot tell what is true and what is not. (PJMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

28) In math, the average person cannot tell what is true and what is not. (PJMRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

29) In history, the truth means different things to different people. (SCH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

30) In political science, the truth means different things to different people (SCH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

31) To do well in history class, the main thing you need to do is memorize facts (SCHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

32) To do well in political science class, the main thing you need to do is memorize facts (SCHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

33) In history, what is true today will be true tomorrow (SCHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

34) In political science, what is true today will be true tomorrow (SCHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

35) In history, the facts do not change (SCHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

36) In political science, the facts do not change (SCHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

37) There are some things in history that we will never understand (SCH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

38) There are some things in political science that we will never understand (SCH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

39) If two historians disagree about some part of history, one of them must be wrong (SCHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

40) If two political scientists disagree about some part of political science, one of them must be wrong (SCHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

41) If a historian says something is a fact, I believe it (JAH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

42) If a political scientist says something is a fact, I believe it (JAH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

43) I think the things written in history textbooks are true (JAH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

44) I think the things written in political science textbooks are true (JAH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

45) If my friend and I disagree about something we learned in history class, we just have to ask the teacher to tell us who is right. (JAH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

46) If my friend and I disagree about something we learned in political science class, we just have to ask the teacher to tell us who is right. (JAH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

47) I don't believe everything I learn in history class. (JAHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

48) I don't believe everything I learn in political science class. (JAHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

49) I don't automatically believe whatever my history teacher tells me. (JAHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

50) I don't automatically believe whatever my political science teacher tells me. (JAHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

51) In history, you just have to decide what you believe and what you do not. (PJH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

52) In political science, you just have to decide what you believe and what you do not. (PJH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

53) In history, if you believe something is true, no one can tell you that you are wrong. (PJH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

54) In political science, if you believe something is true, no one can tell you that you are wrong. (PJH)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

55) In history, the average person cannot tell what is true and what is not. (PJHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

56) In political science, the average person cannot tell what is true and what is not. (PJHRC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

57) Everybody agrees what movies are good and which are bad. (SCARC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

58) Everybody agrees what songs are good and which are bad. (SCARC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

59) Everybody agrees what paintings are good and which are bad. (SCARC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

60) Everybody agrees what food tastes good and which tastes bad. (SCARC)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

61) Movie critics know whether a movie is good or not. (JAA)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

62) Music critics know whether a song is good or not. (JAA)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

63) Art critics know whether a painting is good or not. (JAA)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

64) Food critics know whether a kind of food tastes good or not. (JAA)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

65) If I don’t like a movie, no one can tell me I am wrong. (PJA)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

66) If I don’t like a song, no one can tell me I am wrong. (PJA)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

67) If I don't like a painting, no one can tell me I am wrong. (PJA)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

68) If I don't like some kind of food, no one can tell me I am wrong. (PJA)

1	2	3	4	5	6	7
Completely Disagree			Neither Disagree Nor Agree			Completely Agree

69) Please indicate your grade in school or whether you are in college or graduate school:

70) Please indicate your sex: Male, Female, Transgendered

71) Please indicate your age:

72) Please write down any science, math, political science, and history classes you have taken in the last year.

73) Please indicate your current GPA:

Appendix B: *Pilot Middle-school and High-school Parental/Guardian Consent Form*

Identification of Project	**Epistemic and Ontologic Cognition Questionnaire**
Statement of Age of Participant	Signing this document acknowledges that you are over 18 years of age and wish to give permission for your child to participate in a program of research being conducted by Dr. Roger Azevedo at the Graduate School, University of Maryland, College Park, Department of Human Development.
Purpose	The purpose of this research is to assess students' understanding of various kinds of knowledge.
Procedures	The procedures will involve filling out a survey questionnaire. An example of a question from the questionnaire is: "In physics, the truth means different things to different people." Your child will be rating items on a scale of 1-7, with 1 being completely disagree and 7 being completely agree. There are a total of 69 items that should take about 10-20 minutes to complete. In addition there are 5 demographic items. Your child will be asked to think out loud as you complete the survey. After completing the survey your child will be asked some questions regarding the survey itself which may take up to 30 minutes. An example question is: "What are your overall impressions of the questionnaire?" Your child will be audiotape recorded. You or your child may decide to terminate your child's participation at any time.
Confidentiality	All information collected in the study is confidential, and your child's name will not be identified with his or her responses at any time. A numeric code will be used as identification on data collection materials. Once data are collected, this code will be used for maintenance and analysis of data. Only aggregate data and pseudonyms will be used in publications and conference papers. Survey questionnaire materials will be viewed only by Dr. Roger Azevedo and Jeff Greene (the student investigator) in the College of Education). All materials will be kept in a locked storage area in the Cognition and Technology Lab (Benjamin Building, Rm. # 0313) to which only Dr. Azevedo and his graduate research assistants have keys. Only the investigator and his graduate student will have access to the audiotape, and this audiotape will be kept for three years before being destroyed.
Risks	There are no known risks associated with participation in this research.
Benefits: Freedom to Withdraw and Ask Questions	This experiment is not designed to help you or your child personally, but the investigators hope to learn more about people's views of knowledge. Your child's participation in this research is completely voluntary. You or your child may choose not to take part at all. If your child decides to participate in this research, he or she may stop participating at any time.
Compensation	There is no compensation provided for participating in this study.

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Tel: 301-651-9210
E-mail: jgreene@umd.edu

Contact Information of Institutional Review Board:
If you have questions about your rights as a research subject or wish to report a research-related injury, please contact: Institutional Review Board Office, University of Maryland, College Park, MD 20742; (e-mail) irb@deans.umd.edu; (telephone) 301-405-0678

Printed Name of Participant: ______________________________

Signature of Participant: ______________________________

Date: ______________________________

Appendix C: *Pilot Middle-school and High-school Assent Form*

INSTITUTE:	University of Maryland
PRINCIPAL INVESTIGATOR:	Dr. Roger Azevedo
STUDY TITLE:	Epistemic and Ontologic Cognition Questionnaire

Assent for Epistemic and Ontologic Cognition Questionnaire

INTRODUCTION

We would like you to be in a study to find out more about how people think about various kinds of knowledge. This will involve you filling out a questionnaire and then answering some questions that the researchers will ask you about the questionnaire. Filling out the questionnaire and answering these questions should take about 50 minutes.

WHAT YOU WILL DO IN THE STUDY

You will complete one pencil and paper questionnaire called the Epistemic and Ontologic Cognition Questionnaire. This questionnaire asks questions about how you feel about certain views you might have about different things like school subjects or music. Then the researcher will ask you questions about what you thought about the questionnaire such as whether it was easy to fill out and if you understood all of the questions. You will be audiotaped while you fill out the questionnaire and answer the researcher's questions afterward. The researcher will ask you to "think out loud" as you fill out the questionnaire. This is basically like saying out loud everything that you think in your head.

CONFIDENTIALITY

The fact that you are participating in the study will be kept confidential (secret or private), unless we are required by law to disclose it. When the results of the study are published, the people who take part are not named. No one will ever know that you are in the study unless you and your parents decide to tell them. The only people who will be able to see the information are the research team members. The only time we would break this rule would be if you or a family member tells us information that we think your parents need to know to be able to keep you or other people safe. We would also break this rule if you or a family member tells us information on the questionnaire that would warrant a mental health diagnosis (depression for example). If this happens a researcher will meet with your parents and will provide them with a doctor that will be able to help. The only other time we may break this rule is if there is some evidence that you are or have been abused. If there is evidence that you have been abused we are required by law to tell the proper authorities.

WHAT YOU MAY NOT LIKE

Sometimes it gets boring to answer all of the questions, but we ask that you try hard to do them anyway. If you get tired while completing the questionnaire, you can quit at any time. By being in the study you will help the researchers understand how people think about knowledge. Although it may not help you directly, it may help other children in the future.

You will not be paid for your involvement in this portion of the study.

It is important for you to remember that you are volunteering for this study and you can stop doing it at any time.

If you have any questions, here is where you can contact us:

Principal investigator:
Dr. Roger Azevedo
University of Maryland
College of Education
Department of Human Development
3304 Benjamin Building, room 3304E
College Park, MD 20742
Tel: 301-405-2799
E-mail: razevedo@umd.edu

Institutional Review Board
2100 Lee Building
University of Maryland
College Park, MD 20742-1131
301-405-4212

I have had this study explained to me in a way I understand, and I have had the chance to ask questions. I agree to take part in the study. I understand that I can stop the study at any time if there is something I don't like.

Signature of Participant: ____________________________ Date: ______________

Signature of Investigator: ___________________________ Date: ______________

Appendix D: *Pilot Graduate and Undergraduate Student Consent Form*

Identification of Project	**Epistemic and Ontologic Cognition Questionnaire**
Statement of Age of Participant	You state that you are over 18 years of age and wish to participate in a program of research being conducted by Dr. Roger Azevedo at the Graduate School, University of Maryland, College Park, Department of Human Development.
Purpose	The purpose of this research is to assess students' understanding of various kinds of knowledge.
Procedures	The procedures will involve filling out a survey questionnaire. An example of a question from the questionnaire is: "In physics, the truth means different things to different people." You will be rating items on a scale of 1-7, with 1 being completely disagree and 7 being completely agree. There are a total of 69 items that should take about 10-20 minutes to complete. In addition there are 5 demographic items. You will be asked to think out loud as you complete the survey. After completing the survey you will be asked some questions regarding the survey itself which may take up to 30 minutes. An example question is: "What are your overall impressions of the questionnaire?" You will be audiotape recorded. You may decide to terminate your participation at any time.
Confidentiality	All information collected in the study is confidential, and your name will not be identified with your responses at any time. A numeric code will be used as identification on data collection materials. Once data are collected, this code will be used for maintenance and analysis of data. Only aggregate data and pseudonyms will be used in publications and conference papers. Survey questionnaire materials will be viewed only by Dr. Roger Azevedo and Jeff Greene (the student investigator) in the College of Education). All materials will be kept in a locked storage area in the Cognition and Technology Lab (Benjamin Building, Rm. # 0313) to which only Dr. Azevedo and his graduate research assistants have keys. Only the investigator and his graduate student will have access to the audiotape, and this audiotape will be kept for three years before being destroyed.
Risks	There are no known risks associated with participation in this research.
Benefits: Freedom to Withdraw and Ask Questions	This experiment is not designed to help you personally, but the investigators hope to learn more about people's views of knowledge. Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not lose any benefits to which you otherwise qualify.
Compensation	There is no compensation provided for participating in this study.

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Contact Information of Institutional Review Board:
If you have questions about your rights as a research subject or wish to report a research-related injury, please contact: Institutional Review Board Office, University of Maryland, College Park, MD 20742; (e-mail) irb@deans.umd.edu; (telephone) 301-405-0678

Printed Name of Participant: ______________________________

Signature of Participant: ______________________________

Date: ______________________________

Appendix E: *Dissertation Version of the Epistemic and Ontological Cognition Questionnaire*

The final dissertation version of the EOCQ that follows is annotated to illustrate which dimension and content area each item assesses. After each item is a code representing the dimension that is being measured: simple and certain knowledge (SC), justification by authority (JA) and personal justification (PJ). Items that are reverse-coded are indicated with an (RC).

<u>The Academic Beliefs Questionnaire</u>

1) In math, the truth means different things to different people. (SCRC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

2) To know math well, you need to memorize what you are taught. (SC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

3) In math, what is a fact today will be a fact tomorrow. (SC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

4) Mathematicians' knowledge of the facts about math does not change. (SC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

5) Math is so complex that humans will never really understand it. (SCRC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

6) If a mathematician says something is a fact, I believe it. (JA)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

7) Things written in math textbooks are true. (JA)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

8) I believe everything I learn in math class. (JA)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

9) If a math teacher says something is a fact, I believe it. (JA)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

10) In math, everyone's knowledge can be different because there is no one absolutely right answer. (PJ)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

11) In math, if you believe something is a fact, no one can prove to you that you are wrong. (PJ)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

12) In math, what's a fact depends upon a person's point of view. (PJ)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

13) Mathematical knowledge is all factual and there are no opinions. (PJRC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

14) In history, the truth means different things to different people. (SCRC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

15) To know history well, you need to memorize what you are taught. (SC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

16) In history, what is a fact today will be a fact tomorrow. (SC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

17) Historians' knowledge of the facts about history does not change. (SC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

18) History is so complex that humans will never really understand it. (SCRC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

19) If a historian says something is a fact, I believe it. (JA)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

20) Things written in history textbooks are true. (JA)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

21) I believe everything I learn in history class. (JA)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

22) If a history teacher says something is a fact, I believe it. (JA)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

23) In history, everyone's knowledge can be different because there is no one absolutely right answer. (PJ)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

24) In history, if you believe something is a fact, no one can prove to you that you are wrong. (PJ)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

25) In history, what's a fact depends upon a person's point of view. (PJ)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

26) Historical knowledge is all factual and there are no opinions. (PJRC)

1	2	3	4	5	6
Completely Disagree	Mostly Disagree	Somewhat Disagree	Somewhat Agree	Mostly Agree	Completely Agree

27) Please indicate your current level of education:

Middle-school
High-school
College Freshman
College Sophomore
College Junior
College Senior
Graduate School

28) Please indicate your sex: Male, Female

29) Please indicate your age:

30) Please indicate your current overall GPA:

31) Please circle what grades you usually get in <u>math</u> classes:

Almost All A's
Mostly A's with some B's
Almost All B's
Mostly B's with some C's
Almost All C's
Mostly C's with some D's
Almost All D's or F's

32) Please circle what grades you usually get in <u>history</u> classes:

Almost All A's
Mostly A's with some B's
Almost All B's
Mostly B's with some C's
Almost All C's
Mostly C's with some D's
Almost All D's or F's

33) Please indicate your major (if you are a college or graduate student):

Appendix F: *Assent and Consent Forms*

Appendix B: Middle School and High School Assent Form

INSTITUTE: University of Maryland
PRINCIPAL INVESTIGATORS: Dr. Judith Torney-Purta and Dr. Roger Azevedo
STUDY TITLE: The Academic Beliefs Questionnaire

Assent for The Academic Beliefs Questionnaire

INTRODUCTION

We would like you to be in a study to find out more about how people think about various kinds of knowledge in different subject areas taught in school. This will involve you filling out a questionnaire. Filling out the questionnaire should take about 20 minutes.

WHAT YOU WILL DO IN THE STUDY

You will complete one pencil and paper questionnaire called the Academic Beliefs Questionnaire. This questionnaire asks questions about how you feel about certain views you might have about different school subjects.

CONFIDENTIALITY

The fact that you are participating in the study will be kept confidential (secret or private), unless we are required by law to disclose it. When the results of the study are published, the people who take part are not named. No one will ever know that you are in the study unless you and your parents decide to tell them. The only people who will be able to see the information are the research team members. The only time we would break this rule would be if you or a family member tells us information that we think your parents need to know to be able to keep you or other people safe.

WHAT YOU MAY NOT LIKE

Sometimes it gets boring to answer all of the questions, but we ask that you try hard to do them anyway. If you get tired while completing the questionnaire, you can quit at any time. By being in the study you will help the researchers understand how people think about knowledge. Although it may not help you directly, it may help other children in the future.

You will not be paid for your involvement in this portion of the study.

It is important for you to remember that you are volunteering for this study and you can stop doing it at any time.

INITIALS: __________

If you have any questions, here is where you can contact us:

Principal investigators:
Dr. Judith Torney-Purta
University of Maryland
College of Education
Department of Human Development
3304 Benjamin Building
College Park, MD 20742
Tel: 301-405-2806
E-mail: jtpurta@umd.edu

Dr. Roger Azevedo
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3693 Norriswood Ave.
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Tel: 901-678-4417
Email: razevedo@memphis.edu

Institutional Review Board
2100 Lee Building
University of Maryland
College Park, MD 20742-1131
301-405-4212

I have had this study explained to me in a way I understand, and I have had the chance to ask questions. I agree to take part in the study. I understand that I can stop the study at any time if there is something I don't like.

Signature of Participant: ______________________________ Date: __________

Signature of Investigator: ______________________________ Date: __________

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NOV - 2 2007
UNIVERSITY OF MARYLAND
COLLEGE PARK

Appendix A: Middle School and High School Parental/Guardian Consent Form

Identification of Project

The Academic Beliefs Questionnaire

Statement of Age of Participant

Signing this document acknowledges that you are over 18 years of age and wish to give permission for your child to participate in a program of research being conducted by Dr. Judith Torney-Purta at the Graduate School, University of Maryland, College Park, Department of Human Development and Dr. Roger Azevedo at the Department of Psychology at the University of Memphis.

Purpose

The purpose of this research is to assess students' understanding of various kinds of knowledge in different subject areas taught in school.

Procedures

The procedures will involve filling out a survey questionnaire. An example of a question from the questionnaire is: "In math, the truth means different things to different people." Your child will be rating items on a scale of 1-6, with 1 being completely disagree and 6 being completely agree. There are a total of 33 items that should take about 10-20 minutes to complete. You or your child may decide to terminate your child's participation at any time. The reading level is appropriate for middle-school through graduate students.

Confidentiality

All information collected in the study is confidential, and your child's name will not be identified with his or her responses at any time. A numeric code will be used as identification on data collection materials. Once data are collected, this code will be used for maintenance and analysis of data. Only aggregate data and pseudonyms will be used in publications and conference papers. Survey questionnaire materials will be viewed only by Dr. Judith Torney-Purta, Dr. Roger Azevedo and Jeff Greene (the student investigator) in the College of Education. All materials will be kept in a locked file cabinet in my office located in the Department of Human Development, 3304S Benjamin Building. The surveys will be kept for five years before being destroyed.

Risks

There are no known risks associated with participation in this research.

Benefits: Freedom to Withdraw and Ask Questions

This experiment is not designed to help you or your child personally, but the investigators hope to learn more about people's views of knowledge and education in different subject areas. Your child's participation in this research is completely voluntary. You or your child may choose not to take part at all. If your child decides to participate in this research, he or she may stop participating at any time.

Compensation

There is no compensation provided for participating in this study.

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E-mail: jgreene@umd.edu

Contact Information of Institutional Review Board:

If you have questions about your rights as a research subject or wish to report a research-related injury, please contact: Institutional Review Board Office, University of Maryland, College Park, MD 20742; (e-mail) irb@deans.umd.edu; (telephone) 301-405-0678

Printed Name of Participant: ______________________

Signature of Participant: ______________________

Date: ______________________

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Appendix C: College and Graduate Student Consent Form

Identification of Project

The Academic Beliefs Questionnaire

Statement of Age of Participant

You state that you are over 18 years of age and wish to participate in a program of research being conducted by Dr. Judith Torney-Purta at the Graduate School, University of Maryland, College Park, Department of Human Development and Dr. Roger Azevedo at the Department of Psychology at the University of Memphis.

Purpose

The purpose of this research is to assess students' understanding of various kinds of knowledge in different subject areas taught in school.

Procedures

The procedures will involve filling out a survey questionnaire. An example of a question from the questionnaire is: "In math, the truth means different things to different people." You will be rating items on a scale of 1-6, with 1 being completely disagree and 6 being completely agree. There are a total of 33 items that should take about 10-20 minutes to complete. You may decide to terminate your participation at any time. The reading level is appropriate for middle-school through graduate students.

Confidentiality

All information collected in the study is confidential, and your name will not be identified with your responses at any time. A numeric code will be used as identification on data collection materials. Once data are collected, this code will be used for maintenance and analysis of data. Only aggregate data and pseudonyms will be used in publications and conference papers. Survey questionnaire materials will be viewed only by Dr. Judith Torney-Purta, Dr. Roger Azevedo, and Jeff Greene (the student investigator) in the College of Education. All materials will be kept in a locked file cabinet in my office located in the Department of Human Development, 3304S Benjamin Building. Only the investigators and their graduate student will have access to the questionnaire, and this questionnaire will be kept for five years before being destroyed.

Risks

There are no known risks associated with participation in this research.

Benefits: Freedom to Withdraw and Ask Questions

This experiment is not designed to help you personally, but the investigators hope to learn more about people's views of knowledge and education in different subject areas. Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not lose any benefits to which you otherwise qualify.

Compensation

There is no compensation provided for participating in this study.

Dr. Judith Torney-Purta	Dr. Roger Azevedo	Jeffrey A. Greene
University of Maryland	University of Memphis	University of Maryland
College of Education	Department of Psychology	College of Education
Department of Human Development	3693 Norriswood Ave.	Department of Human Development
3304 Benjamin Building	Memphis, TN 38152-6400	3304 Benjamin Building
College Park, MD 20742	Tel: 901-678-4417	College Park, MD 20742
Tel: 301-405-2806	Email: razevedo@memphis.edu	Tel: 301-651-9210
E-mail: jtpurta@umd.edu		E-mail: jgreene@umd.edu

Contact Information of Institutional Review Board:

If you have questions about your rights as a research subject or wish to report a research-related injury, please contact: Institutional Review Board Office, University of Maryland, College Park, MD 20742; (e-mail) irb@deans.umd.edu; (telephone) 301-405-0678

Printed Name of Participant: ____________________________

Signature of Participant: ____________________________

Date: ____________________________

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Appendix G: *Descriptive Statistics for the Dissertation Version of the EOCQ by Educational Level*

Middle School Students

Item	Mean	Standard Deviation	Skewness	Kurtosis
1	4.10	1.146	-.732	.969
2	4.48	1.331	-1.117	.637
3	4.63	1.296	-1.104	.704
4	3.72	1.462	-.240	-.877
5	2.31	1.389	.950	.133
6	4.31	1.106	-.857	1.035
7	4.43	1.159	-.783	.233
8	4.83	1.189	-.982	.556
9	4.76	1.052	-.908	.956
10	3.65	1.660	-.163	-1.150
11	2.73	1.428	.388	-.816
12	3.59	1.386	-.231	-.561
13	3.85	1.464	-.276	-.783
14	4.65	1.090	-1.034	1.504
15	4.54	1.233	-.902	.682
16	4.30	1.460	-.566	-.589
17	3.56	1.531	-.210	-1.009
18	2.93	1.398	.290	-.830

19	4.54	.949	-.471	.155
20	4.54	1.045	-.520	.087
21	4.64	1.081	-.650	179
22	4.69	1.012	-.704	.291
23	3.88	1.360	-.304	-.747
24	3.18	1.397	.221	-.665
25	3.61	1.436	-.112	-.885
26	3.70	1.397	-.303	-.689

High School Students

Item	Mean	Standard Deviation	Skewness	Kurtosis
1	2.97	1.471	.228	-1.017
2	4.32	1.234	-.602	-.305
3	4.84	1.150	-1.001	.556
4	3.67	1.393	-.346	-.808
5	3.43	1.463	1.161	-.912
6	3.85	1.299	-.426	-.430
7	4.24	1.050	-.470	-.115
8	4.24	1.33	-.782	.119
9	4.22	1.207	-.745	.219
10	2.69	1.349	.557	-.518
11	2.20	1.099	.705	-.142
12	2.42	1.257	.638	-.400
13	4.39	1.279	-.619	-.367
14	4.94	1.214	-1.309	1.376
15	4.49	1.113	-1.013	1.254
16	4.24	1.506	-.642	-.612
17	2.72	1.452	.541	-.627
18	2.99	1.581	.430	-.962
19	3.81	1.141	-.118	-.564
20	3.84	1.244	-.269	-.823

21	3.97	1.289	-.512	-.371
22	4.02	1.110	-.407	-.372
23	3.97	1.426	-.389	-.682
24	2.69	1.223	.386	-.640
25	3.99	1.368	-.434	-.474
26	2.46	1.299	.762	-.102

Undergraduate Students

Item	Mean	Standard Deviation	Skewness	Kurtosis
1	2.55	1.302	.529	-.799
2	4.08	1.329	-.602	-.469
3	4.71	1.111	-1.217	1.364
4	3.80	1.320	-.221	-.815
5	2.87	1.279	.436	-.544
6	4.05	1.098	-.677	.161
7	4.38	.907	-.893	1.648
8	4.39	1.038	-.600	.419
9	4.20	1.049	-.884	.864
10	2.60	1.165	.755	.196
11	2.25	1.030	.813	.806
12	2.39	1.088	.851	.524
13	4.14	1.204	-.442	-.390
14	5.00	.952	-.969	.949
15	4.29	1.139	-.699	.498
16	3.65	1.455	-.070	-.904
17	2.72	1.293	.583	-.378
18	3.12	1.298	.301	-.538
19	3.50	1.084	-.219	-.282
20	3.65	1.064	-.326	-.109

21	3.55	1.153	-.285	-.391
22	3.78	1.047	-.486	.278
23	4.18	1.258	-.462	-.408
24	2.66	1.120	.232	-.703
25	4.23	1.215	-.517	.079
26	2.43	1.164	.657	-.035

Graduate Students

Item	Mean	Standard Deviation	Skewness	Kurtosis
1	3.07	1.485	.144	-1.357
2	3.76	1.204	-.389	-.745
3	4.19	1.249	-.821	.060
4	3.26	1.222	.139	-.611
5	2.71	1.214	.714	.350
6	3.71	1.170	-.487	-.501
7	4.14	.907	-1.158	1.583
8	4.05	1.176	-1.175	1.028
9	3.98	.927	-.786	1.231
10	2.79	1.176	.767	.406
11	2.24	1.081	.704	-.093
12	2.75	1.199	.238	-1.050
13	3.07	1.323	.152	-.746
14	5.16	.894	-1.078	1.425
15	3.91	1.247	-.395	-.270
16	2.86	1.395	.415	-.623
17	2.12	1.283	1.025	.028
18	3.35	1.316	.044	-.544
19	2.97	.991	-.154	-1.090
20	2.89	.994	-.573	-.657

21	2.66	1.101	.488	.222
22	2.97	1.184	-.260	-.863
23	4.36	1.210	-.620	.476
24	2.66	1.278	.737	.120
25	4.41	1.325	-.909	.668
26	1.79	.913	1.003	.887

Glossary

Adaptive: a term adopted in this dissertation to capture development through the model, intended as an alternative to "availing" (see below)

Availing: literally means helpful or beneficial; used by Muis (2004) as a term for the upper ends of continua describing epistemological beliefs, it has the benefit of not being tied to age or development as other terms used to describe the advanced ends of these continua, such as "mature" or "sophisticated"

Defeasible: falsifiable; used in reference to knowledge claims, it is the idea that one can claim 'knowledge' of something, with all the attendant privileges of claiming 'knowledge' but also acknowledge that that knowledge is potentially incorrect pending additional information

Epistemic Cognition: a term put forth by Kitchener (2002) that he feels more accurately describes the work of personal epistemology, epistemological beliefs, and epistemological theories researchers

Epistemology: literally the study of knowledge; a branch of philosophy that deals with how people go about determining what is knowledge (Pollock & Cruz, 1999; Williams, 2001)

Epistemological Beliefs: a model put forth by Schommer (1990) that personal epistemology is a multidimensional phenomenon comprised of five independent factors

Ill-structured Problem: a problem that has no single, clear answer; a problem that is more subjective than objective; a problem on which reasonable people can disagree (Frederiksen, 1984)

Ontology: a branch of philosophy that examines what actually exists and the categories or classes of that which exists (Pollock & Cruz, 1999)

Personal Epistemology: a field of research based primarily in educational psychology that explores "how individuals come to know, the theories and beliefs they hold about knowing, and the manner in which such epistemological premises are a part of and an influence on the cognitive processes of thinking and reasoning" (Hofer & Pintrich, 1997, p. 88).

Relativism: a term with different meanings in psychological and philosophical; epistemology research:

a) Psychological Relativism: one scheme within Perry's (1970, 1999) model of personal epistemology that emphasizes that knowledge claims can be evaluated *relative* to some set of standards and/or criteria

b) Philosophical Relativism: the belief that "knowledge" is only true for a particular person or culture; knowledge as an objective truth cannot and does not exist (Williams, 2001)

1) Philosophical Relativism most resembles Perry's Multiplicity position, *not* his Relativism position

Skepticism: the philosophical view that "knowledge" cannot be known by humans and that it may indeed not even exist; skeptics also doubt the value of objective knowledge, claiming that local understandings are more useful (Williams, 2001)

Theory of Mind: an area of research that explores how young children move from a naïve understanding of the world as objectively and directly known to a more nuanced view of the world that can include false beliefs, interpretation, and constructivism (Chandler et al., 2002)

Well-structured Problem: a problem that has a single, clear answer; a problem that is more objective than subjective; a problem on which reasonable people can agree (Frederiksen, 1984)

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