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TEACHER EPISTEMIC BELIEFS:

THE DEVELOPMENT OF A PSYCHOMETRICALLY SOUND MEASURE

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Abstract

This dissertation study is an investigation of *teacher epistemic beliefs*. *Teacher epistemic beliefs* are defined as the beliefs teachers have about the justification of knowledge and how those beliefs are evidenced in their pedagogical practices. Much of the current research in educational psychology has focused on the beliefs of students (e.g., Cano, 2005; Hofer, 2000; Perry, 1970; Schommer, 1990) However, the beliefs of teachers are important to study because it is those beliefs that influence students' beliefs (Hofer, 2001). Thus, the purpose of this dissertation study is to create and investigate the psychometric properties of a new measurement system designed to assess *teacher epistemic beliefs* as they are defined in the philosophical literature. The sample for this dissertation study included both preservice and inservice teachers involved in a Professional Development School program. Results of the data analyses show that the scores from the Likert-type items created for this study were both internally consistent and stable over time. In addition, profiles of *teacher epistemic beliefs* were created in a reliable way using content-free Likert-type items for both preservice and inservice teachers. However, when content teaching was introduced into the items reflecting pedagogical practices, the reliability of participants' scores were less than optimal. Finally, the results of this study show that when teachers provide a detailed description of their lessons and pedagogical practices, the measurement system created was able to show that preservice teachers' epistemic beliefs are espoused and enacted in similar ways.

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CHAPTER 1

INTRODUCTION

This dissertation study is an investigation of the beliefs teachers hold relative to their pedagogical practices. Beliefs have solid literature bases in both philosophy and in educational psychology, and have been investigated in a number of different ways. For the philosophers, beliefs are the primary topic in the discipline of epistemology. Epistemology is the study of the nature of knowledge and knowing (Pollock & Cruz, 1999), where knowledge is defined as *justified true belief* (Moser, 1995; Pollock & Cruz, 1999).

The study of epistemology in the philosophical areas includes two primary branches related to the definition of knowledge. Specifically, epistemologists are interested in either the study of the truth of knowledge, or investigations of how knowledge is justified. In this dissertation study, the justification condition will be investigated. Justification refers to the actions a person takes or the conditions they hold to show that they have a belief that is true. Specifically, conditions of justification can differ based upon the types of evidence that are accepted to show that one holds a true belief. Varying types of evidence are accepted by philosophers, depending upon the epistemological framework to which they adhere. For this dissertation study, the justification conditions for three epistemic frameworks (i.e., *foundationalism*, *coherentism*, and *reliabilism*) will be used to investigate teachers' beliefs. These three epistemic frameworks are used for this study because they are well-matched to the pedagogical practices teachers may employ in their classrooms to help students change their conceptions or to gain new knowledge (Murphy, Alexander, Greene, & Edwards, 2007). The

justification conditions differentiating each of these three epistemic frameworks are highlighted later in this chapter.

Epistemology has also been investigated by researchers from educational psychology, but in ways that differ from the rational speculations (Alexander, 2006) held by philosophers. Whereas philosophers have deduced arguments about the nature of knowledge and the nature of the justification conditions, psychologists have investigated different beliefs to which individuals hold. A number of different models of these beliefs are found in the psychological literature on "personal epistemology." According to Kitchener (2002), the term "personal epistemology" may not correctly represent the construct of interest. Kitchener states that one's "personal epistemology" would be their personal beliefs about the field of epistemology. According to Kitchener, the use of this term would suggest that individuals logically speculate about knowledge in the same manner as philosophers.

Instead, educational psychologists study what Kitchener (2002) calls "epistemic beliefs." These are beliefs about an individual has about knowledge itself, what knowledge is, and how it is justified. In this dissertation study, the term "epistemic beliefs" will be used to refer to such beliefs when appropriate. Specifically, when researchers investigate participants' beliefs about knowledge, the term "epistemic beliefs" will be used to refer to such beliefs.

In the psychological literature, epistemic beliefs are investigated in a number of different ways. In contrast to the study of beliefs by philosophical epistemologists, educational psychologists have investigated epistemology by defining models of these knowledge beliefs that are either unidimensional or multidimensional in nature. The dimensionality of these beliefs refers to the number of factors inherent in the conceptualizations of beliefs. These psychological

researchers have also investigated the extent to which these knowledge beliefs are domain-general or domain-specific in nature.

Researchers investigating beliefs in the personal epistemology literature have primarily investigated students' beliefs. According to Hofer (2001), students' beliefs about knowledge are influenced by the beliefs teachers hold and the pedagogical practices they employ in their classrooms (see Figure 1). These pedagogical practices have been studied extensively by researchers who examine expertise in teaching (e.g., Shulman, 1987). Because the pedagogical practices of teachers directly impact student learning, it is important to investigate these practices, and the beliefs of teachers that influence these practices (Hofer, 2001).

Thus, for this dissertation, an initial investigation as to the epistemic beliefs of teachers will be conducted. Specifically, a new measurement system will be created to assess teachers' beliefs about knowledge and the use of evidence. These beliefs will be assessed as they relate to teachers' pedagogical practices, and will be designed to reflect the justification conditions found in the philosophical literature on epistemology. In addition, the instrument created in this dissertation study will be designed to produce profiles of beliefs that are both reliable and valid. Thus, a measurement system that offers researchers a system of reliable and valid indicators that assesses *teacher epistemic beliefs* is the primary contribution of this dissertation.

Epistemology: Definitions from the Philosophical Literature

Epistemic beliefs have been defined and theorized about extensively in the philosophical literature throughout the ages. Unlike the research in the educational psychology literature, much of the focus of this work has been about the conditions under which knowledge is considered to be justified. Different philosophers propose varying methods as to how individuals provide justification for their beliefs. Thus, a number of different frameworks for the justification of

knowledge exist within the philosophical literature. Three of these frameworks, *foundationalism*, *coherentism*, and *reliabilism* are directly applicable to education (Murphy et al., 2007).

The first of these frameworks, *foundationalism*, is the traditionally-accepted belief about the justification of knowledge. For *foundationalists*, knowledge has a hierarchical structure (Moser, 1995), with some beliefs about knowledge being basic and central to all other beliefs. *Foundationalists* can only say they are justified in having knowledge if they can connect their new knowledge back to the basic beliefs. These basic beliefs are those that are seen as fundamental pieces of information that are accepted as true (Fumerton, 2000). Because of the reliance on an individual's beliefs as evidence for having knowledge, the justification condition for *foundationalism* is internal to the knower.

The second of the philosophical frameworks, *coherentism*, differs from *foundationalism* in that there are no central beliefs. In other words, knowledge for *coherentists* consists of a system of beliefs with each belief providing justification for all other beliefs in the system (Kvanvig, 1986a, 2003). One is said to be justified in having knowledge if he or she can connect their new knowledge back to all other beliefs in the system. Again, because of the reliance on an individual's beliefs, the justification condition for *coherentism* is internal.

For philosophers who hold to a *reliabilist* epistemic framework, knowledge is justified based upon that which is external to the knower (Bach, n.d.). In other words, evidence for having knowledge cannot be based upon the belief of the individual knower. Instead, data external to the knower must be collected. In order to provide justification, then, the individual's hypothesis is compared to the observable data. If the observable data supports the hypothesis, a *reliabilist* would consider the person to be justified in their belief.

Although much work has taken place by philosophers to logically deduce the justification conditions that must be met for each of these three epistemic frameworks, philosophers have not investigated these beliefs using the measurement techniques that are forwarded in the psychological literature. However, clear definitions of these epistemic frameworks have been forwarded in the literature.

Conceptions of Epistemology by Psychological Researchers

Researchers in educational psychology have conceptualized epistemic beliefs differently from those theorists in philosophy. Varied models of epistemic beliefs have been forwarded that are either unidimensional or multidimensional in nature with regard to their factor structure. In this section, I will review unidimensional and multidimensional models of beliefs. There are two types of multidimensional models, those that are domain-general, and those that are domain-specific in nature. Both types of models will be reviewed here.

Early Work in Personal Epistemology: Unidimensional Models

Beginning with the work of Perry in the 1960s and 1970s, the epistemic beliefs literature in educational psychology has grown substantially. Early work in this area consisted of the development of a number of models of epistemic beliefs that are unidimensional in nature. Although not assessed with quantitative data, researchers have conceptualized unidimensional beliefs as having only one belief factor encompassing all the beliefs a person has about the nature of knowledge and knowledge acquisition. Individuals are thought to develop on this single belief factor over time from being naïve to more sophisticated. Naive beliefs are considered to be those where an individual accepts the positions and knowledge of others without question. They see the world in terms of absolutes. Individuals who have more sophisticated beliefs, on the other hand, do not see knowledge as being absolutely correct or incorrect. Rather, people with more

sophisticated beliefs are able to determine differences in individuals' ideas based upon the reasons they have for coming to a conclusion. For researchers investigating epistemic beliefs in a unidimensional manner, profiles of the degree to which these beliefs are sophisticated were built using data collected through interviews of primarily undergraduate students

A number of limitations in the data collection and measurement systems used to develop these epistemic belief profiles can be identified. For example, the fact that data collection is primarily confined to undergraduate students is a limitation of these unidimensional models. Unidimensional models of epistemic beliefs were supposedly conceptualized from the data collected; yet, data was not collected to develop all belief profiles in these models. For example, Perry (1970) extends his model to include beliefs of students that were not present in the data collected from the participants. In addition, with the exception of work by Baxter Magolda (1992), primarily qualitative interview data is collected and analyzed. Although the use of qualitative data analyses procedures in itself is not a limitation, triangulation of the results based upon different types of data are rarely employed in the studies. Thus, it is difficult to determine whether the epistemic belief positions accurately describe the beliefs of the participants. Because of these methodological limitations, the reliability and validity of the scores of the results in these studies cannot be established.

Another major limitation to the work completed by researchers investigating unidimensional conceptions of epistemic beliefs is the fact that the nature of the reasons used by individuals classified as having more sophisticated epistemic beliefs are not investigated. Individuals who have more sophisticated beliefs are identified as such because they differentiate between opinions and ideas based upon reasons and evidence. For example, Belenky and her colleagues (1986) who are classified as *constructed knowers* report that justification for

knowledge is completed within the context of the problem. However, the researchers do not investigate the nature of the justification conditions used by individuals having sophisticated beliefs.

Like the work completed by authors investigating unidimensional conceptions of epistemic beliefs, the research completed for this dissertation study profiles the epistemic beliefs of teachers. Unlike the work completed by the aforementioned authors, the profiles established in this dissertation are not unidimensional in nature, nor are they conceptualized on a continuum from naive to sophisticated beliefs. In addition, the work completed in this dissertation study profiles teachers based upon their use of differing justification conditions, which differs from the nature of the profiles constructed by researchers investigating unidimensional frameworks.

A Contrasting Framework for Personal Epistemology: Multidimensional Models

In contrast to these unidimensional epistemic belief frameworks are those that are multidimensional in nature. Multidimensional belief models, such as the one proposed by Schommer (1990, 1993), consist of a number of different belief dimensions that are hypothesized to be independent of each other. From a measurement perspective, a person's epistemic beliefs in a multidimensional system consist of a number of independent belief factors such that scores represent more than one trait. These beliefs may not all develop into being sophisticated beliefs at the same rate. Instead, some of an individual's beliefs may be naive and others may be more sophisticated at any given time. Two types of multidimensional models, those that are domain-general and those that are domain-specific, will be overviewed here.

Domain-general beliefs. In order to investigate nature of epistemic beliefs conceptualized in a multidimensional way, Schommer created a new instrument (1990) assessing these beliefs using Likert-type items. Schommer conceptualized epistemic beliefs as consisting of five diverse

and independent belief factors that all contribute to an individual's epistemic belief framework. Three of these, *Certain Knowledge*, *Simple Knowledge*, and *Omniscient Authority* have been classified as beliefs about the nature of knowledge. The other two factors in her instrument, *Quick Learning* and *Innate Ability*, have been classified as beliefs about the nature of learning.

Participants in Schommer's studies consist mainly of undergraduates (e.g., Schommer, 1990, 1993; Schommer, Crouse, & Rhodes, 1992) or students who are gifted (Schommer & Dunnell, 1994; Schommer & Walker, 1995). For her studies, participants complete a Likert-type questionnaire. Exploratory factor analyses of the instrument using orthogonal rotations have been conducted on twelve subsets of items rather than by individual item (Schommer, 1990, 1993). As a result of this analysis, four of the five hypothesized factors have emerged from the data, with *Omniscient Authority* not emerging. Reliabilities for these factors are at a moderate level, ranging from .63 to .85 for each factor.

Domain-specific beliefs. In order to increase the reliability and validity of scores that may be obtained on measures of epistemic beliefs, a variety of researchers have conceptualized epistemic beliefs in a domain-specific way. Thus, researchers have developed a number of other instruments to assess these domain-specific beliefs. One such instrument, developed by Buehl and her colleagues (2002) assessed beliefs in a multidimensional manner about the contents of mathematics and history. The instrument was validated for use with undergraduate students, and consisted of Likert-type items. Results of this research showed that beliefs can be considered to be domain-specific in nature, with factors assessing integrating information and problem solving being identified for each of the two content areas (Buehl et al., 2002). When attempting to validate the scores obtained from this instrument for use with eighth and ninth grade participants, the factor structure did not hold (Murphy, Edwards, Buehl, & Zeruth, in press).

Similar to the work of Buehl and her colleagues (2002), Hofer (2000) created an instrument assessing domain-specific epistemic beliefs of undergraduate students about the contents of psychology and science. As with the instruments developed by Schommer (1990) and Buehl and her colleagues (2002), Hofer assessed these beliefs using Likert-type items. Four factors representing the epistemic beliefs of undergraduate participants (i.e., *Certain/simple knowledge; Justification for knowing: Personal; Source of knowledge: Authority; Attainability of truth*) were identified in the validation study for this scores from this instrument. These four factors align with the factors of epistemic beliefs identified by Hofer and Pintrich (1997) in their review of the literature.

Although much research has been conducted to assess multidimensional conceptions of epistemic beliefs, a number of limitations are evident. First, participants in studies of multidimensional belief frameworks are primarily undergraduate students. Exceptions to this are studies investigating the beliefs of adults (Schommer, 1998) or gifted students (Schommer & Dunnell, 1994; Schommer & Walker, 1995). Very rarely are the beliefs of other groups of individuals, including the beliefs of teachers, assessed, although the beliefs of teachers may contribute to the beliefs of students (Hofer, 2001).

Second, the only types of items used to assess the epistemic beliefs of participants in multidimensional models of beliefs are Likert-type items. No other approaches to data collection were utilized by any authors. No measures of demonstrated beliefs are forwarded in the literature; thus, epistemic beliefs are established solely through self-report data. In addition, the construct validity of the scores obtained from using some of these instruments may be called into question because the belief factors obtained from using these multidimensional assessments are

rarely replicable by other researchers (e.g., Jehng, Johnson, & Anderson, 1993; Qian & Alvermann, 1995).

Like the work of researchers who investigate epistemic beliefs as they are conceptualized in a multidimensional way, the work in this dissertation also conceives of *teacher epistemic beliefs* as being multidimensional in nature. However, a number of differences are present, both in the conceptualization of the factors comprising epistemic beliefs and in the methods used to assess those factors. First, the dimensionality of teachers' beliefs is limited to an investigation of the differing conditions for justification that they use in their pedagogical practices. Second, both domain-general and domain-specific conceptions of epistemic beliefs are assessed in this dissertation study. Some items assessing teachers' beliefs about different types of justification conditions were used in a domain general way. Other items assessing pedagogical practices in science content areas were also developed for this study. The content of science was chosen because many of the studies assessing domain-specific beliefs (e.g., Conley et al., 2004; Tsai, 1997) address individuals' beliefs about science. These items were written to reflect practices and content that would be appropriate in a fourth grade classroom because this is the grade level at which science is assessed by the state in which the schools are located (Pennsylvania Department of Education, 2002). In addition, both Likert-type and rank-scaled type items were used to assess *teacher epistemic beliefs* as they are evidenced in teachers' pedagogical practices. Finally, self-report data was collected in addition to data on teachers' demonstrated pedagogical practices to determine teachers' epistemic belief profiles.

Statement of the Problem

The number of studies in the personal epistemology literature has grown substantially from the onset of Perry's work in the late 1960s and early 1970s. Yet, there are a number of

limitations in the measurement techniques used by researchers investigating epistemic beliefs. The purpose of this dissertation study will be to develop a measurement system to acquire scores that represent *teacher epistemic beliefs* relative to their pedagogical practices.

This dissertation contributes to the literature on personal epistemology in several unique ways. The first way is in the investigation of beliefs from a population not previously studied in-depth, that of teachers. The beliefs of teachers affect their choices of pedagogical practices which, in turn, affect the beliefs of the students in their classes (Hofer, 2001). Although the beliefs of teachers have been stated to be an important influence on the beliefs of students (Schommer, 1990), investigations of *teacher epistemic beliefs* have been neglected in the literature. Even though the majority of the sample employed for this dissertation study consists of undergraduates, these undergraduates have specific training as teachers. This characteristic is not present in most of the undergraduate samples employed in the current epistemic beliefs literature.

Second, because the epistemic beliefs of teachers affect their pedagogical practices, it is important that those beliefs be investigated relative to pedagogical practices. The pedagogical practices assessed in this dissertation are aligned with the conceptions of justification forwarded by philosophers in their investigations of epistemology. This is an important contribution to the literature because teachers' beliefs have not previously been assessed relative to their pedagogical practices. In addition, the beliefs and pedagogical practices of teachers may differ depending upon the experience level of the teachers. Thus, the beliefs of both preservice and inservice teachers will be investigated in this study.

Finally, the reliability and validity of the scores obtained from previous investigations of epistemic beliefs have been called into question (e.g., Hofer & Pintrich, 1997). This dissertation

will make a contribution to the literature by introducing a new measurement system consisting of novel item formats and statistical analyses procedures designed for assessing *teacher epistemic beliefs*. The use of these item formats and statistical analyses, coupled with an investigation into the demonstrated practices of teachers has not been completed before in the literature in either philosophy or educational psychology.

Purpose of the Study

Thus, the purpose of this dissertation is to create a new psychometrically sound instrument designed to assess *teacher epistemic beliefs*. Specifically, an investigation of the reliability and convergent validity of the scores obtained from this instrument is the primary focus of this dissertation study. In addition, the validity of the science content and that of the epistemic frameworks are established. Novel methodologies are used to establish the belief profiles obtained from the Likert-type and rank-scaled items, as well as from the practices demonstrated by teachers. The reliability and convergent validity of scores obtained from the assessment is also assessed. Specifically, reliability is established first be addressing the accuracy by which classifications of epistemic belief profiles can be made. The internal consistency of scores obtained from the newly created assessment will be established, as will the stability of those scores over time as well as from different types of items. Profiles of teachers' beliefs will be created as they are enacted in their practices, which has not been done previously in the literature. In addition, it is not yet known whether scores obtained on the newly created instrument will be related to scores on previously validated instruments assessing the justification of knowledge. Thus, the relations between the results of the newly created instrument and other instruments in the personal epistemology literature assessing the use of differing justification conditions (i.e., Conley, Pintrich, Vekiri, & Harrison, 2004; Elby, n.d.;

Hofer, 2002) will also be investigated to further investigate the convergent validity of the scores on the instrument.

Research Questions

The following research questions related to the reliability and validity of the scores on the newly created instrument will be investigated to address the purposes of the study.

1. *Reliability*
    a. To what extent are teacher epistemic frame profiles consistent across item type and within selected pedagogical practices?
        i. To what degree can belief profiles be identified for Likert-type items?
        ii. To what degree can belief profiles be identified for each epistemic framework across science content areas in the rank-scaled items?
        iii. To what degree can descriptions of lessons given on the constructed response items be rated similarly by independent raters?
    b. To what extent does the instrument produce internally consistent scores to assess *teacher epistemic beliefs* as measured by the Likert-type items?
    c. To what extent does the instrument provide stable scores of *teacher epistemic beliefs* as measured by the Likert-type and rank-scaled items?
2. *Convergent Validity*
    a. To what extent do teachers' reported epistemic frame scores relate to one another?
    b. To what degree are the responses of the various measures developed in this instrumentation system related to one another?
    c. To what extent do teachers' reported epistemic beliefs correlate with conceptions of justification assessed in the literature on personal epistemology?

Definition of Key Terms

Coherentism – According to *coherentists*, there are no basic or non-basic beliefs; all beliefs are justified and justify other beliefs identically within the system (Kvanvig, 2003). For *coherentists*, justification is internal to the knower.

Epistemic beliefs – Epistemic beliefs are defined as those beliefs one may have about knowledge itself (Kitchener, 2002).

Epistemological beliefs – Epistemological beliefs are defined as the beliefs an individual may have about the field of epistemology and the study of knowledge (Kitchener, 2002).

Epistemology – Epistemology refers to the branch of philosophy that studies the nature of knowledge and justified belief (Steup, 2001).

Foundationalism – According to *foundationalists*, basic beliefs are those which are accepted as true without question or doubt. All beliefs that are not basic must be justified based upon these basic beliefs (Fumerton, 2000). For *foundationalists*, justification is internal to the knower.

Multidimensional beliefs - Epistemic beliefs are conceptualized as being a number of different, independent belief dimensions. These dimensions form a system of beliefs and may develop at different rates (Hofer & Pintrich, 1997).

Pedagogical practices – Those practices that teachers employ in classroom learning situations to help facilitate the knowledge acquisition of their students (Hofer, 2001).

Personal epistemology – In the literature, the term *personal epistemology* refers to all beliefs individuals have about the nature of knowledge and of knowing. According to Kitchener (2002), the use of this term is not correct. However, because of its widespread use in the educational psychology literature, the term *personal epistemology* will be used throughout this dissertation study to refer to the body of literature on epistemic beliefs found in the psychological literature.

Reliabilism – According to *reliabilists*, a belief is justified if an only if it has been formed by either a reliable cognitive process or by a history of reliable cognitive processes (Goldman, 1994). For most *reliabilists*, justification comes through means that are external to the knower.

Teacher epistemic beliefs – Refers to the beliefs teachers have about knowledge and the types of evidence that are considered viable in their classrooms, as well as how those beliefs are operationalized in their pedagogical practices

Unidimensional beliefs - There is only one overarching belief, a single dimension, and it is implied that these beliefs get more sophisticated over time. An individual's epistemic belief is conceptualized as a single construct (Hofer & Pintrich, 1997).

CHAPTER 2

REVIEW OF THE LITERATURE

Epistemology refers to a branch of philosophy focused on the nature, methods, limitations, and validity of knowledge (Moser, 1995). Over the centuries, philosophers have engaged in deliberations over the specific nature of knowledge and how it relates to similar notions such as truth, belief, and justification. Indeed, questions of what it means to *know* have been theoretically pondered since the time of Plato (n.d.). For example, in the *Theaetetus*, Socrates considers a number of theories as to what it means to know, and the result of his contemplation and reflection is that knowledge must be a true belief that is supported, explained, or defined in some way. This understanding that knowledge represents justified true belief is now pervasive and widely-accepted in the contemporary philosophical literature on epistemology. The lingering question for philosophers pertains to the parameters of what counts as justification.

In contrast, psychologists have focused on a different aspect of epistemology. Specifically, 19th and early 20th century psychologists have been more focused on the processes through which one comes to know something than they have been on what it means to know. The result of these extensive lines of inquiry was the proliferation of models of knowledge acquisition (e.g., instrumental conditioning; Thorndike, 1913). Within the last 20 years, educational psychologists have begun to revisit the notion of epistemology and the ways that individuals' epistemic beliefs influence the learning process. Interestingly, with the notable exception of work conducted by myself and my colleagues (Murphy et al., 2007), almost no

educational psychologist has attempted to bridge these vast literatures as a mechanism to better understand learning.

Although the influence of epistemic beliefs in the learning process has recently begun to be studied, researchers have investigated primarily students' epistemic beliefs. However, the epistemic beliefs of teachers play an important role in the learning process. In her review of the literature, Hofer (2001) theorized that teachers' beliefs influence the types of pedagogical practices they will choose to employ in their classrooms. The use of different pedagogical practices will, in turn, impact the learning process in varied ways. Thus, because the use of pedagogical practices directly influences the learning of the students and impacts their epistemic beliefs (Hofer, 2001), it is vital to investigate teachers' beliefs about knowledge and the nature of knowing.

The purpose of this review of literature, then, is to overview relevant theoretical and empirical research on epistemology from the domains of philosophy and psychology, and to use those perspectives as a lens through which to view contemporary perspectives of pedagogical practices prominent in the education literature. Specifically, the pedagogical practices will be explicated with an eye toward how they are influenced by teachers' beliefs and how they influence students' beliefs.

In this chapter, the philosophical literature on epistemology will first be overviewed. Although a number of frameworks of epistemology are forwarded in the philosophical literature, three will be described in detail. These three epistemic frameworks, *foundationalism*, *coherentism,* and *reliabilism* will be reviewed in this chapter because their use is directly applicable to the processes teachers use to change students' knowledge (Murphy et al., 2007).

Models of epistemic beliefs, or personal epistemology (Hofer, 2000), as detailed in the psychological literature will next be identified. First, prominent empirically derived unidimensional models (i.e., Baxter Magolda, 1992; Belenky et al., 1986; King & Kitchener, 1994; Kuhn, 1991; Perry, 1970) will be reviewed. Both the conceptual underpinnings and purpose of each model will be highlighted. The methods used to establish each of the models will be investigated, along with the results of the study. Each of the positions or stages in these unidimensional models will be described. Because of the methodological nature of this dissertation study, limitations inherent in the methods and analyses for the development of each of these unidimensional models studies will be reviewed.

The next part of this literature review will consist of an extensive examination of Schommer's (1990, 1993) multidimensional model of epistemic beliefs. In this section, I will evaluate her model of epistemic beliefs, as well as the methods used to test this model. Uses of Schommer's (1990, 1993) instrument by other researchers will then be reviewed. Studies investigating the changes in individuals' knowledge beliefs over time, as assessed using Schommer's instrument, will then be reviewed. Methodological limitations of Schommer's (1990, 1993) instrument including the problems with the data analysis and validity of the factor structure will then be examined.

The third section of this literature review will consist of an examination of the personal epistemology literature that is domain-specific in nature. In this section, domain differences as investigated by researchers using Schommer's (1990, 1993) instrument will be reviewed. Epistemic beliefs in the domain of science will then be evaluated (e.g., Hammer, 1994; Elby, n.d., Tsai, 1997), followed by a review of the literature on instruments written specifically to assess epistemic beliefs in a domain-specific way (Buehl et al., 2002; Hofer, 2000).

After appraising the many models of epistemic beliefs in the personal epistemology literature, a number of conflicts were found. Specifically, the differences between unidimensional and multidimensional models will be reviewed, followed by the differences between domain-general and domain-specific conceptions and measurements of epistemic beliefs. Finally, teachers' beliefs are rarely studied in this literature, yet their beliefs are important and may relate to the beliefs of students (Hofer, 2001). Thus, the studies investigating *teacher epistemic beliefs* will be examined. The literature review will be concluded with a description of pedagogical practices (i.e., traditional practices, constructivism, and persuasive pedagogy) that are accepted by some as being effective in classrooms.

Inclusion and Exclusion Criteria

The breadth and depth of literature in the area of personal epistemology is growing quickly. For this review, however the most influential and prevalent conceptions of epistemic beliefs were included. The first of these are conceptions of epistemology found in the philosophical literature. Buehl and Alexander (2001) have stated that it is important to look to the philosophical literature when researching epistemic beliefs, although this is rarely pursued. Thus, in this literature review, three epistemological frameworks, namely *foundationalism*, *coherentism*, and *reliabilism*, have been reviewed for this study. Specifically, the work of contemporary theorists such as Moser (1995), Kvanvig (1986a), and Shogenji (2001) were investigated for this dissertation study.

In the psychological literature, a number of different researchers have investigated epistemic beliefs, and those models were included in this review. Specifically, Perry's (1970) model was included because of the significant contribution made to the literature. It is widely accepted that much of the personal epistemology literature currently available has stemmed from

this work (Hofer & Pintrich, 1997). The work of a number of different researchers (i.e., Baxter Magolda, 1992; Belenky et al., 1986; King & Kitchener, 1994; Kuhn, 1991) was also included in this review because some of the beliefs in these unidimensional models are conceptualized differently than that of Perry. In addition, in some cases (e.g., Belenky et al., 1986), the sample used is substantially different from Perry, leading to the inclusion of the models. Although there may be other unidimensional models of beliefs, these five models are the most widely known in the epistemic beliefs literature.

Schommer-Aikins' (1990, 1993, 2004) multidimensional model of epistemic beliefs was also included in this review. This is the most well-known and widely used model of beliefs, and is quite influential in the literature. Schommer-Aikins was also one of the first researchers to create a paper-and-pencil measure of epistemic beliefs. Because of the portability of Schommer-Aikins' measure, a number of different researchers (e.g., Qian & Alvermann, 1995; Rukavina & Daneman, 1996) have attempted to use her measure, or translations of their measure (e.g., Clarebout, Elen, Luyten, & Bamps, 2001), in their research. This literature was included in this review. In addition, all literature attempting to create new instruments using Schommer-Aikins' conceptual model (e.g., Schraw, Bendixen, & Dunkle, 2002; Buehl et al., 2002) was reviewed.

A number of domain-specific studies on epistemic beliefs were also investigated. Specifically, literature from psychological researchers such as Hofer (2000) and Buehl and her colleagues (2002) was assessed here. In addition, a number of different studies of epistemic beliefs from content areas, like science education (e.g., Tsai, 1997), were reviewed here. This literature is important to include because teachers are being studied along with their pedagogical practices in science.

In addition, the most influential work on three pedagogical frameworks (i.e., traditional pedagogical practices, constructivism, and persuasive pedagogical practices) was reviewed for this dissertation study. Work from some of the most seminal researchers advocating constructivism (i.e., Cobb & Steffe, 1983; von Glaserfeld, 1991) was identified for this literature review. For the pedagogical practices that are more traditional in nature, the work of the teacher efficacy literature was reviewed, specifically the work of Tschannen-Moran and Woolfolk Hoy (2001). Teacher efficacy is operationalized by a number of pedagogical practices that are considered effective by almost all teachers (Edwards, Higley, Zeruth, & Murphy, 2007). The teacher efficacy instrument developed by Tschannen-Moran and Woolfolk Hoy (2001) was reviewed for this study because it was developed in collaboration with inservice teachers. The entirety of the literature on teaching as persuasion (e.g., Fives & Alexander, 2001; Murphy, 2001) was reviewed for this study for pedagogical practices that are persuasive in nature.

Epistemic Beliefs: A Philosophical View

The construct of epistemology has been studied for many centuries by philosophers. Epistemology is an important area in the philosophical literature, characterized by three defining questions: *What is the nature of knowledge*; *what is the source of knowledge*; and, *what are the limits of knowledge* (Bonjour & Sosa, 2003; Moser, 1995; Pollock & Cruz, 1999). To determine the answers to those three questions, philosophers begin with the definition that knowledge is "justified true belief" (DeRose, 2004; Moser & vander Nat, 2003). That is, in order for a proposition to be considered knowledge for a person, that proposition must be true, it must be believed by the person, and the person must be able to justify that knowledge in some way. Philosophers attempt to logically deduce the conditions that must be present to establish both the truth of knowledge and justification of that knowledge. For this dissertation study, the

justification of knowledge will be addressed. The justification of knowledge consists of those conditions that must be met to support or explain a true belief, and is an important component in determining whether one can claim they have knowledge.

Most philosophers agree that in order for a proposition to be knowledge, it must be both true and believed by the person. It is the justification condition for knowledge upon which the epistemic beliefs of people differ (Murphy et al., 2007). There are many methods for justifying knowledge, and three of the epistemic beliefs with subsequent methods for justifying knowledge will be discussed in this literature review. Brief definitions for these epistemic frameworks are given below.

Foundationalism – perceptions based upon sensory experiences are enough for knowledge to be justified, and foundational beliefs upon which everything else builds are available (Fumerton, 2000).

Coherentism – perceptions based upon sensory experiences are enough for knowledge to be justified provided that the beliefs are coherent, or in line with every other belief in the knowledge system (Kvanvig, 2003; Young, 2001).

Reliabilism – knowledge is justified by comparing the answer obtained through reliable cognitive processes with data observed through naturalistic inquiry (Steup, 2001).

These three epistemic frameworks were chosen for analysis in this dissertation study because they appear to be most applicable to conceptual change (Murphy et al., 2007) and to education in general. In other words, the definitions of these epistemic frames are such that these types of justification conditions would be easy for teachers to use in their classrooms. This is opposed to epistemic frameworks such as *virtue epistemology* (Greco, 2002), where justification is based upon the character of an individual, or *evolutionary epistemology* (Bradie & Harms,

2004), where justification is based upon the assertion that the cognitive structures of individuals have evolved over time.

The three epistemic frameworks addressed in this study fall into two categories of beliefs (i.e., doxastic and non-doxastic). People who hold to doxastic views on the nature of justification believe that the only viable mechanism for the justification of knowledge is through perceptual experience (i.e., *foundationalism* and *coherentism*). These views are widely held, but are subject to what is known as the Gettier problem (e.g., Moser, 1995). Gettier (1963) demonstrated that the three conditions for knowledge (i.e., truth, belief, and justification), were not sufficient for claims about knowledge because knowledge could be justified based upon coincidental happenings. Gettier (1963) suggested that other conditions were necessary for knowledge to be justified. Non-doxastic beliefs about the nature of justification (i.e., *reliabilism*) provide conditions other than only perceptual experience upon which justification must rely. For example, *reliabilists* contend that knowledge is justified through comparing answers obtained through cognitive processes with observed data. The three epistemic frameworks to be investigated for this dissertation study, *foundationalism*, *coherentism*, and *reliabilism* will be described in detail.

Foundationalism

The study of epistemology began in philosophical discussions with a framework known as *foundationalism*. For *foundationalists*, knowledge has a structure, or hierarchy. According to *foundationalists* (Moser, 1995), justified beliefs are either basic or non-basic. In other words, basic beliefs are those that are non-inferential, upon which non-basic beliefs rest.

Basic beliefs are those that are non-inferential. This means that these beliefs are self-evident (Murphy et al., 2007). These beliefs are self-evident because they do not require the

person's other beliefs for justification. Often, justification for these self-evident, basic beliefs comes from experience, meaning that the knower has a perceptual experience leading them to create a basic belief. According to Moser (1995), this type of justification method for basic beliefs is found in *experience foundationalism*. Justification comes from the experience of the knower on how the object appears to them. Basic beliefs in *experience foundationalism* consist of beliefs about objects external to the knower.

Internal mental states can also be justified as basic beliefs in what is known as *privilege foundationalism.* According to Moser (1995), these basic internal beliefs do receive justification, but not from the knower's other beliefs. Rather, the knower privileges some beliefs over others, possibly because they were told by a source of authority or through a textbook. These privileged beliefs become the foundational beliefs upon which other beliefs subsequently rest.

Whichever method of justification is used to develop basic, foundational beliefs, the beliefs share characteristics. First, they are considered non-inferential, meaning the knower does not have to infer anything to "know" the basic belief (Fumerton, 2000). Second, the basic beliefs are infallible, indubitable, and incorrigible (Fumerton, 2000; Moser, 1995). In other words, because of the nature of the basic beliefs, they cannot be false, doubted, or corrected by others. What is important to remember is that these beliefs are infallible because they are not about the object itself but, rather, they are about a person's perception of the object. For beliefs counted as basic by *experience foundationalism*, this is because the beliefs are based upon the perceptions of the individual which no other person can access. For beliefs counted as basic by *privilege foundationalism*, different beliefs may be privileged by individuals, which cannot be argued with.

Whichever method is used for forming foundational beliefs, non-basic beliefs rest upon them and are justified by them (Kvanvig, 1986a). According to Kvanvig (1986a), most things we know have such a status because we know other propositions. *Foundationalists* are able to trace a line of justification for their beliefs back to the original, basic beliefs. When they are able to do this, they count the new knowledge as being justified. Thus, "[a]ccording to *foundationalism*, all justification is ultimately traceable to the foundations of justification. Thus, all justified beliefs form a structure for there simply cannot be any justified beliefs not linked to the foundations" (Kvanvig, 1986a, p. 346).

Many times, this line of justification includes inferences because the person using foundational methods for justification must accept other propositions as infallible and having non-inferential justification if they are to be justified in holding their non-basic belief. For example, a person may believe that if a ship sails around the world, they will not fall off the edge. According to *foundationalism*, they are only justified in this belief if they first accept some other infallible belief, such as that the Earth is round (which would be justified most likely through privilege methods). In this way, *foundationalists* usually use non-deductive methods to justify their non-basic beliefs (Moser, 1995). Whereas basic beliefs are infallible, non-basic beliefs are subject to error because of the role of inference.

Coherentism

Not all philosophers agree with this *foundationalist* view of epistemic justification. Some epistemologists suggest that, although knowledge may be gathered through our perceptual experiences, privileged beliefs do not exist (Moser, 1995). In this view, called *coherentism*, beliefs do not necessarily exhibit a hierarchical structure. Rather, *coherentists* assert that knowledge is structured more like a web (Moser, 1995), with all beliefs carrying equal weight

(Kvanvig, 1986a). In other words, there are no basic or non-basic beliefs; all beliefs are justified and justify other beliefs identically within the system (Kvanvig, 2003).

For *coherentists*, justification for beliefs consists solely of the relations among those beliefs (Shogenji, 2001, in press). In other words, beliefs that are connected generate justification for the beliefs within the system (Shogenji, 2001). In fact, Shogenji states beliefs exhibit a greater level of justification with more beliefs in the system. Shogenji argues that more knowledge is gained using this type of justification than in *foundationalism*. This is because *foundationalists* use the same beliefs over and over for justification. Shogenji (2001) argues that in a coherent system, knowledge is added because beliefs may have different justifications, and then receive *more* justification from each other, thus adding new knowledge to the system. In this way, the more beliefs that cohere, the more justification for the system (Shogenji, in press).

There are two main types of *coherentism*. The first is *doxastic coherentism*, or when every justified belief receives justification from the beliefs in its vicinity (Moser, 1995). For *doxastic coherentism*, a person forms a belief about how an object appears based upon their perception of that object. The person may be justified in this belief because the perceptual experience is best explained by assuming it represents the truth (*explanatory coherentism*), or because the person generally believes their perceptual experiences to be reliable based upon past success or memory (*reliability coherentism*). Either way, *coherentism* is at work because the new perceptually based experience is being justified based upon a larger network of previously justified beliefs.

For the second type of *coherentism*, *dependence coherentism*, justification for a belief comes from the justification you have for other beliefs (Moser, 1995). This justification can come from other types of evidence, such as perceptual experiences or memory, but the

justification does *not* have to come from other beliefs. Although this sounds similar to *reliability coherentism*, it is different because *reliability coherentism* would require a *belief* that the perceptual experiences or memory is reliable. *Dependence coherentism* does not require such a belief.

Reliabilism

In line with Gettier's (1963) criticisms outlined previously, the problem some epistemologists have with *foundationalism* and *coherentism* is that there is no guarantee of truth to the system of beliefs (Steup, 2001). There are a growing number of epistemologists who believe the bases for justification in the *foundationalist* and *coherentist* frameworks cannot help the knower with the goal of believing truth and avoiding error (Kvanvig, 1986b). Instead, some type of justification outside the knower's perceptual experiences must be used. One epistemic framework dedicated to providing justification outside perceptual experiences is that of *reliabilism*.

For *reliabilists*, a belief is justified if an only if it has been formed by either a reliable cognitive process or by a history of reliable cognitive processes (Goldman, 1994, as cited in Beebe, 2004). Justification, then, comes from the quality of a person's epistemic action (Bach, n.d.).

In *reliabilism*, the quality of a person's epistemic action comes from either personal or procedural reliability. *Personal reliability*, or a dependence on a person's intellectual capabilities for accepting truth and avoiding error (Kvanvig, 1986a), appears to be an internalist view of *reliabilist* justification (Bach, n.d.). By this, it is meant that when a person is justified in their knowledge, the rational process used by the person is known and available for use (Bach, n.d.).

In other words, the knower takes responsibility for being justified in holding a belief and uses their rational cognitive processes.

Procedural reliability, on the other hand, appears to be an externalist view of *reliabilist* justification. According to Bach (n.d.), externalist views are views by which beliefs are justified, rather than by which people are justified in holding beliefs. In *procedural reliabilism*, beliefs are justified based upon the efficacy of the procedure used to accept truth and avoid error (Kvanvig, 1986a). This type of *reliabilism* appears to be more prevalent in the literature (e.g., Bach, n.d., Beebe, 2004). In fact this method of *reliabilism* appears to also be used in assessing justification in science education (e.g., Conley et al., 2004).

Whether *foundationalism*, *coherentism*, or *reliabilism* is used, it is important from an epistemic perspective that knowledge beliefs are justified in some way. According to Weiner (2005), "Epistemologists should worry about whether beliefs have a certain property only if that property is a good property for beliefs to have…. 'justification' can be used to pick out such a property" (p. 423). If justification can be used epistemically to determine whether or not a belief is good or bad, true or false, it then makes sense that we may want to use justification in classrooms to determine whether or not students have true or false beliefs about their knowledge. However, the degree to which individuals hold to differing philosophical epistemic frameworks has not been tested by philosophers in studies in the way that psychologists assess the beliefs of students. In addition, psychological researchers (e.g., Schraw, 2001; Schommer, 1990) state that teacher epistemic beliefs should be studied because of their influence on both student beliefs and learning (Hofer, 2001). Thus, the purpose of this dissertation study is to link teacher epistemic beliefs with the identified philosophical epistemic frameworks.

Epistemic Beliefs: A Historical View of Psychological Definitions

Unidimensional Models of Epistemic Beliefs

Epistemic beliefs have been researched in ways other than rational thought processes by educational psychologists in the literature on personal epistemology. The onset of the work in epistemic beliefs began with a number of researchers studying models of epistemic beliefs that are unidimensional in nature. For these researchers, epistemic beliefs are conceptualized as being only one belief dimension that develops over time. According to researchers studying epistemic beliefs in a unidimensional fashion, individuals move a long a continuum of beliefs from naive beliefs to those beliefs that are more sophisticated in nature. In this part of the literature review, I will review five of the most popular unidimensional models. Specifically, I will briefly review the purpose for each study, the methods employed by the researcher in the study to develop the models, the epistemic positions or stages identified by the researcher, and methodological limitations of each of the studies.

William Perry's scheme of intellectual development. The role that individuals' beliefs about knowledge play in the psychological literature was first investigated by William Perry, and was explicated in detail in his 1970 book entitled "Forms of Intellectual and Ethical Development in the College Years." Perry felt that individuals move through a set of positions in their intellectual development. Although Perry himself did not make any claims as to the developmental nature of his model, the positions are hierarchically structured, making suggestions as to the development of knowledge beliefs. The content of these positions regarded the nature of knowledge. Individuals, in Perry's conceptualization, moved through the developmental positions because a series of new experiences instigate a change their thinking prompting them to reorganize information. This action moved individuals to a more

sophisticated belief along the developmental continuum. In order to do this, Perry stated that there must be congruence between what a person brings to an experience and what they discern about the environment during the experience. The nature of the congruence between these two dimensions determined the sense the person makes from the experience.

In his study, Perry documented the college experiences of undergraduates enrolled at Harvard in the late 1960s. One-hundred nine male students participated in the study, with 67 participating for four years. Participants were interviewed at the end of each school year. To begin the interviews, Perry and the other interviewers asked participants, "Why don't you start with whatever stands out for you about the year?" (p. 19) Follow-up questions were then asked to provide participants the opportunity to elaborate on their answers; however, Perry deliberately refused students' requests for more specific questions. From the answers provided, Perry explicated a model of intellectual development that has been used as the foundation for much of the later research on epistemic beliefs.

Specifically, Perry proposed a unidimensional framework for investigating individuals' beliefs about knowledge (see Table 1 for a description of the epistemic positions). That is to say, according to Perry, epistemic beliefs develop into different positions along a continuum. As with other unidimensional models (e.g., King & Kitchener, 1994; Kuhn, 1991), Perry proposed a sequence of observable structures in beliefs that change through an orderly process by which more complex forms of knowledge are created through simpler forms of knowledge. These epistemic positions were organized in such a way that their structure "will refer specifically to the formal properties of the assumptions and expectancies a person holds at a given time in regard to the nature and origins of knowledge and value" (Perry, 1970, p. 42). In fact, if any true

"definition" of epistemic beliefs is offered by Perry, it is that these beliefs refer to the assumptions people make about the nature of knowledge and the origin of value.

Table 1

Epistemic Positions in Perry's (1970) Scheme of Intellectual Development

Epistemic Position	Description	Justification
Dualism	Correct answers exist for every question, and it is the job of students to learn these truths.	Justification occurs because the correct answer comes from those in authority.
Multiplism	Truths exist for every question, but may not have been found yet. Diverse opinions exist because truth has not yet been found.	No authorities exist. All beliefs are equally valid.
Relativism	People are entitled to their own opinions. The issues are inaccessible and will continue to be, so no correct answers exist.	Justification occurs within the context of the issue, as long as the belief can be defended.

From the interview data he collected, Perry developed a scheme of intellectual development grounded in individuals' views of knowledge. Perry described a 9-position continuum of beliefs, with positions 1 and 9 being explicated to finish the development of the continuum. In positions 1 through 3, students' positions are interpreted as moving from strict dualism to simple forms of multiplism. Although no students were in position 1, *Basic Duality* when interviewed, many stated they were in this position at the beginning of their college experience. Students who were dualists saw the world in a manner where there exists a correct answer for every question, and the authorities have those answers. It is the job of students to

learn the truths given to them by authorities. Individuals could then move to less dualistic positions 2 and 3, entitled *Multiplicity Pre-Legitimate*, where diverse opinions are perceived but are considered incorrect or unreal; and *Multiplicity Subordinate*, where a "truth" may be perceived for every question, but authorities may not have found the answers yet.

Students moved from pre-multiplist positions then into position 4, entitled *Multiplicity Correlate* (or *Relativism Subordinate*), which is a true multiplist position. In this position, students recognized that people have the right to their own opinions. Most of the uncertainty and diverseness of opinions was seen as existing because the truth of issues at hand is inaccessible currently and will continue to be in the future. From this, students moved into a position of *Relativism* where all knowledge was seen as contextual, and opinions were intrinsically motivated rather than being given or prompted from authority figures. The rest of Perry's belief positions were actions that can be completed once a person has moved into a relativistic position (i.e., *Commitment Foreseen, Initial Commitment*, *Orientation in Implications of Commitment*, and *Developing Commitment*). People in these positions were able to balance the benefits and negative implications of the commitments they have made and identified themselves by and through these commitments. These positions described how people made decisions rather than their beliefs about knowledge.

Methodological limitations of Perry's scheme of intellectual development. Perry's (1970) developmental scheme was abstracted from participants' answers to open-ended interview questions. Although this type of theory-building work is beneficial in education, there are a number of limitations to his study. First, it is unclear *how* the scheme was abstracted. Perry provides no description of the analysis techniques used to develop the scheme. Thus, the guiding qualitative research framework used to develop the positions was not explicated. In addition,

Perry did not begin his study with the intent of developing a scheme to begin the work on epistemic beliefs. Although it may have changed slightly for each of the participants, Perry neglected to provide a description of his interview scheme. In addition, no other data was collected for triangulation purposes, calling into question the accuracy of the results. Further calling into question the reliability and accuracy of the results was the fact that Perry acknowledges that the opinions and values of the researchers may have influenced the responses of the participants during the interviews.

Further limitations are evident in the developmental scheme itself. Specifically, positions 1 and 9 were extrapolated from extensions of the data; there were no participants who exhibited these epistemic positions. Thus, it is not clear as to whether or not these positions exist in the ways explicated by Perry in an undergraduate population. In addition, the data was collected at the end of each school year, so there was no way for Perry to be able to tell how participants' developed throughout college. In other words, no baseline data was collected. Instead, students were only given the opportunity to self-report their change throughout the year. It is not clear as to whether the data that was collected accurately represents belief change throughout participants' first year of college.

Women's ways of knowing. Other researchers have studied these epistemic beliefs in varied ways. Belenky and her colleagues (1986) identified some limitations in Perry's sample. Specifically, they wanted to conduct a similar study to investigate the epistemic beliefs of women because they felt that women's beliefs may be substantially different from those of men. Because Perry studied the epistemic beliefs of only men who were enrolled at Harvard, Belenky and her colleagues (1986) felt that there might be elements of epistemic beliefs missing from his framework because of the lack of attention to women's beliefs and experiences. Subsequently,

research was done to determine solely the epistemic beliefs of women, or "Women's Ways of Knowing." This was done because, "…we believe that conceptions of knowledge and truth that are accepted and articulated today have been shaped throughout history by the male-dominated majority culture" (p. 5).

Belenky and her colleagues felt that individuals' conceptions of knowledge evolve over time, leading to changes in their views of themselves as knowers. The difference between the work of Perry and Belenky was that Belenky felt that there were differences in the ways in which women perceived the world; thus, the positions into which their beliefs lie may be different. Thus, Belenky and her colleagues chose 135 women of all educational levels and walks of life to interview to determine their epistemic beliefs. The researchers were looking for what they called *epistemic perspectives*, or those perspectives through which women know and view the world.

In the interviews, Perry's epistemological positions were embedded in the questions so the researchers could determine whether or not women had the same types of views about knowledge as did the men in Perry's study. Table 2 provides a comparison of the epistemic positions of Perry (1970) and Belenky and her colleagues, as well as the positions included in other unidimensional models of epistemic beliefs.

Table 2

Epistemic Belief Positions for Unidimensional Models

Model name (Researcher)	Position 1	Position 2	Position 3	Position 4	Position 5
Perry (1970)		Absolutist	Dualist		*Reliabilist*
Belenky et al. (1986)	Silence	Received Knowledge	Subjective Knowledge	Procedural Knowledge	Contextual Knowledge
King & Kitchener (1994)		Pre-Reflective Thinking	Quasi-Reflective Thinking		Reflective Thinking
Kuhn (1991)	Realist	Absolutist	Multiplist		Evaluativist
Baxter Magolda (1992)		Absolute Knowing	Transitional Knowing	Independent Knowing	Contextual Knowing

Unlike the work of Perry (1970), most of the women in Belenky et al.'s (1986) study were interviewed only one time, and the interviews lasted from two to five hours. The women were told that the researchers were interested in their experiences, and the interviews began with the question, "Looking back, what stands out for you over the past few years?" (p. 11) After the opening question, participants were asked a series of follow-up questions, such as (a) "How do you know what is right/true?" (b) "How do you know someone is an expert?" and (c) "Do you agree with this person who says that where there are no right answers anybody's opinion is as good as another's?" The complete interview scheme is included in the appendix (Belenky et al., 1986, pp. 231-236), and Table 3 presents an overview of the epistemic positions explicated from individuals' responses to the interview.

Table 3

Epistemic Positions in Belenky et al.'s (1986) Model of Women's Ways of Knowing

Epistemic position	Description	Justification
Silence	Women are mindless and voiceless, and are subject to external authority	There is no need for justification, as women are not competent to justify knowledge or accept positions outside authority.
Received Knowledge	Knowledge is received and reproduced. New knowledge is not created by these women.	Authorities hold all correct knowledge.
Subjective Knowledge	Truth is personal and subjective because answers to questions are not yet known.	No authorities exist. They have all failed. All beliefs are valid.
Procedural Knowledge	There are different ways to know and learn, but women are content to use the ways taught to them.	*Separate* – Reasoning alone is used for justification. *Connected* – Emotional connection and personal knowledge are the only viable sources for justification.
Constructed Knowledge	All knowledge is contextual, and the knower is the creator of new knowledge.	Justification occurs within context.

Three phases were used to code the interview data. First, Belenky and her colleagues attempted to use Perry's (1970) coding scheme to code blinded interview data collected from the women. The coding scheme did not fit the data well. In phase two, the categories of Belenky et al.'s coding scheme were delineated, and in phase three, each interview was unblinded and coded in context according to ten bimodal dimensions (e.g., rational v. intuitive; personal v. impersonal; or, being with others v. being alone or on own). The goal of the third phase was to let each woman's voice or experience emerge. Belenky and her colleagues moved back and forth

between the blind and participant-identified codes to determine women's epistemic positions and also be able to hear those positions in context.

Belenky and her colleagues (1986) found that women's beliefs about knowledge comprised five epistemological positions. The first was a position of *silence*. That is, women who experienced themselves as silent believed that they are mindless, voiceless, and subject to the whims of external authority. They saw authorities, mostly men, as having absolute power and the ability to get things done, whereas women should remain passive because they were not competent. As might be expected, the position of *silence* is not reflected in Perry's epistemic framework.

Women who were in the position of *received knowledge* believed that knowledge is received the same way as men in Perry's *dualist* position. Information is received from authorities and is learned and reproduced "as is." These women saw themselves as capable of receiving and reproducing knowledge but not capable of creating knowledge on their own. The *received knowledge* position was also different from the next position, that of *subjective knowledge.* This position was very similar to Perry's multiplist view. In this epistemic position, women saw truth as very personal and subjectively known. Women in this position often painted pictures of "failed male authority" (p. 57). In other words, the male authority figures in these women's lives were not able to provide women with the truth positions they were looking for, so they determined they had to find answers within their own experiences and context.

Belenky et al.'s next epistemic position was *procedural knowledge*. In this position, women were interested in applying objective procedures they learned to obtain and communicate knowledge. These women knew that there were different ways to know and learn, but they were content to use the ways to learn that were taught to them. Two types of procedural knowledge

positions were identified, *separate knowing* and *connected knowing*. Women who were classified as separate knowers were analytic and kept their emotions out of the reasoning process. Connected knowers, on the other hand, believed that "…the most trustworthy knowledge comes from personal experience rather than the pronouncements of authorities" (p. 113). Thus, the procedures developed for gaining and transmitting knowledge reflected this belief in the importance of emotions.

Those women who were classified at the highest level of epistemic beliefs were called *constructed knowers*. Women in this position viewed all knowledge as contextual, and saw themselves as creators of knowledge. Unlike separate and connected knowers, these women possessed the skills necessary to value and use both objective and subjective strategies to gain knowledge.

Methodological limitations of women's ways of knowing. It appears that these five epistemic positions constitute a unidimensional model and that they are on a developmental continuum. However, the researchers acknowledge that limitations in their data collection techniques that do not allow them to make developmental claims. Although the researchers ask participants to recall the last few years, interviews are conducted, for the most part, at a single time point. This type of data collection does not allow the researchers to make developmental claims about the nature of epistemic beliefs, and the researchers acknowledge this. However, throughout the book, Belenky and her colleagues discuss changing beliefs, development of perspectives, and the like. This may stem from the fact that some of the identified beliefs mirror Perry's framework, which is identified as being developmental in nature.

Although Belenky and her colleagues attempt to generalize Perry's (1970) epistemic scheme to women, there are a number of limitations to their study. Like Perry, Belenky and her

colleagues do not collect any other types of data by which to triangulate their results. Thus, the reliability of their conclusions is questionable. Second, although these researchers tell the reader that they used a three-phase coding scheme to analyze the data, they do not provide a detailed explanation of their analysis method. The authors simply state that they explicated five epistemic positions from the parts of the interview on the nature of truth, knowledge, and authority. There is no description of how this was completed.

More importantly, Belenky and her colleagues (1986) claimed to study the epistemic beliefs of many different women, not just those in university settings. Yet, they did not ask the women the same questions. In some cases, the women who were not in school or had not obtained college degrees were not asked as many follow-up questions as the women who had an education. For example, women who did not have an education were not asked their opinions about books (pp. 234-235). Thus, because the same questions were not asked of all women, the authors have automatically biased the more well-developed epistemic positions against women who were not in school.

Reflective judgment model. Perry (1970) and Belenky and her colleagues (1986) both conceptualized developmental models of individuals' epistemic beliefs as stage-like continuums relating to how they conceptualize knowledge. King and Kitchener (1994) sought to add to this conceptualization. King and Kitchener (1994) attempted to extend Perry's (1970) model of beliefs by developing the Reflective Judgment Model (RJM) that focuses on how individuals understand and use justification. Specifically, King and Kitchener (1994) developed a model that focuses on the influence that the criteria for knowing that they hold plays on their judgments. However, the model was not explicated solely for beliefs about academic knowledge. Rather, participants' beliefs about different problems were assessed through responses to an interview.

Responses to the problems (i.e., building of the pyramids, objectivity in news reporting, chemical additives in foods, and the safety of nuclear energy) were assessed to determine what the student felt was the nature of knowledge and the process through which the knowledge was justified. These responses were collected from 80 individuals who participated in at least one testing time over a ten year period, with 38 participating in all four testing times. Participants were mainly undergraduate students and young adults, and participated in the years of 1977, 1979, 1983, and 1987. In the interviews, the ill-structured problems listed above were posed to the participants because the researchers were interested in identifying the methods of justification used that cannot be based solely upon schooled learning. Rather, King and Kitchener (1994) were interested in investigating the methods individuals use to determine a course of action in a novel situation. Participants were first asked, "What do you think about these statements?" King and Kitchener were interested in helping the students explicate their opinions and justify those answers.

After being asked the initial question, six follow-up questions were asked of the participants (p. 102). Specifically, participants were asked:

1. "How did you come to hold that point of view?"
2. "On what do you base that point of view?"
3. "Can you ever know for sure that your position on this issue is correct? How or why not?"
4. "When two people differ about matters such as this, is it the case that one opinion is right and one is wrong?"
5. "How is it possible that people have such different points of view about this subject?"
6. "How is it possible that experts in this field disagree about this subject?"

Depending on their answers, participants were asked follow-up questions. For example, participants who were not able to decide between two completely different opinions on the topics were asked questions that did not vary the opinions as much (p. 103). Epistemic stages are provided in Table 4.

Table 4

Epistemic Stages of King & Kitchener's (1994) Reflective Judgment Model

Epistemic Stage	Description	Justification
Pre-Reflective Thinking	There is a direct correspondence between what a person believes and reality.	Direct observation and external authorities
Quasi-Reflective Thinking	Knowledge is often uncertain, and correct answers do not always exist. Decisions or beliefs are individually made.	Decisions are based on evidence collected in context.
Reflective Thinking	Right and wrong do not exist; the quality of evidence is judged to determine views.	Evaluation of arguments and evidence against each other.

Data from the interviews were independently scored by two raters who were blind to the participants' identity. In addition, the raters were blind to other answers each of the participants had given. In round 1, each of the raters gave seven ratings to each problem. These ratings were then summarized into a three-digit code. Discrepant ratings, or those that were different by more than one stage, were rescored in as many scoring rounds as were necessary. After discrepancies were resolved, the three-digit code was used to summarize the ratings. The average of the two ratings was used for each of the participants on each of the questions.

Seven stages of the unidimensional RJM were identified by King and Kitchener (1994), and were grouped into three categories of reflective judgment (i.e., *Pre-Reflective Thinking*, stages 1-3; *Quasi-Reflective Thinking*, stages 4-5; and *Reflective Thinking*, stages 6-7). In *Pre-Reflective Thinking*, learners justified their knowledge through direct observation, either their own or that of an authority figure. People in these stages saw knowledge as absolute or certain. If any uncertainty was found, it was only because the authorities have not yet found the answer. People in *Quasi-Reflective Thinking* thought that decisions about ill-structured problems should be based upon evidence collected; however, those judgments were seen to be individually made. Justification in these stages was context-specific. Students in the final stages of *Reflective Judgment* saw the importance of justifying knowledge in the context in which the information was collected. People at these stages rejected labels of "right" and "wrong," instead preferring to judge the quality of evidence given when judging viewpoints.

In King and Kitchener's (1994) RJM, methods of justification of knowledge are addressed in a developmental way as people moved through the stages of the model. *In Pre-Reflective Thinking*, justification occurred through direct observations. After moving to *Quasi-Reflective Thinking*, King and Kitchener claim that knowledge was justified by collecting evidence, but that the judgments were made individually and were context specific. Finally, justification in the *Reflective Thinking* stages consisted of the ability to justify knowledge but recognized those justifications hold only within the context in which the information was collected.

Methodological limitations of the reflective judgment model. Of all the unidimensional models, King and Kitchener (1994) provide the most data on the agreement of the ratings between raters. However, it is not at all clear what the three-digit code for summarizing ratings

means or how it was developed. The authors are also not clear as to how they rated the interview responses. They stated that seven ratings were given by each rater that correspond to each of the seven stages of the RJM, but there is no description of how these ratings were given, or the criteria for any of the ratings. By their descriptions, it is also not clear how the ratings correspond to the stages of the RJM. From the brief description of the ratings, it appears that the stages of the model were already explicated before the ratings of the questions were completed. Yet, this is not clear.

Epistemological thinking model. Similar work with justification was completed by Kuhn (1991) in her Epistemological Thinking Model. Although not solely about the justification of knowledge, Kuhn (1991) and her colleagues (e.g., Kuhn & Weinstock, 2002) were interested in modeling on how people develop arguments. Although the development of a model based on acceptable justification was not the goal, Kuhn (1991) sought to model how people reason throughout the life-span. Specifically, Kuhn was interested in how people developed arguments. Kuhn (1991) and her colleagues (e.g., Kuhn & Weinstock, 2002) were interested in investigating the structure of individuals' arguments, as well as how competent they were at argumentative reasoning. This argumentative reasoning was defined as an internal argument. In other words, the purpose of argumentative reasoning was to provide justification for a position and recognize the opposition between two differing positions. Like King and Kitchener (1994), Kuhn (1991) interviewed participants and asked them to respond to ill-structured problems (i.e., prisoners returning to crime, children's failure in school, and unemployment). They were asked to state their positions and justify them with evidence. The researchers were interested in how participants respond to every day, ill-structured problems that have no clear-cut solutions in order to determine the argument structure used by the participants. Participants were also asked

to state a view that opposed theirs, refute that opposing view, and offer a solution for the problem about which they were asked.

Interviews consisted of two types of questions. The first types of questions were stated by Kuhn (1991) to be about causal theory, justification, contradictory positions, and instrumental reasoning. For these types of questions, participants were asked such things as (a), "How do you know that this is the cause?" (b), "If you were trying to convince someone else that your view is right, what *evidence* [verbal emphasis] would you give to try to show this?" or (c), "Is there anything someone could say or do to *prove* that this is what causes prisoners to return to crime?"

The second type of questions were about participants' epistemological reasoning. Participants were asked such things as (a), "Do experts know for sure what causes prisoners to return to crime?" (b), "How sure are you of your view, compared to an expert?", or (c), "Could more than one point of view be right?"

Unlike many of the other frameworks, Kuhn (1991) explicated her analysis in great detail. For the first step, a random selection of 20 protocols was coded for each major skill identified by the author (i.e., causal theories, supporting evidence, alternative theories, counterarguments, and rebuttals). Each rater analyzed the protocols separately and determined a set of categories to account for reasoning. After analyzing protocols separately, the team of researchers collaboratively devised a set of categories from the independent codes. The randomly selected protocols were then coded independently by all group members using the collaboratively-formed set of categories. Discussion was employed to resolve disagreements. After the coding scheme was in place, two coders applied the system independently and met to resolve disagreements until half of all data was coded by two coders. Reliability was calculated on a random 60 sets of data for codes on which skill was being assessed and the epistemic

category to which it belonged. Chi-square tests of independence were used to analyze the data.

Three categories of epistemic beliefs resulted from the data collected (see Table 5), which are similar to those found in other studies (e.g., Perry, 1970; Belenky et al., 1986).

Table 5

Epistemic Positions in Kuhn's (1991) Epistemological Thinking Model

Epistemic Position	Description	Justification
Absolutists	High certainty of knowledge – some facts are primary pieces of knowledge.	Authorities who know the facts.
Multiplists	Everyone has different perspectives on knowledge, and all opinions are equally valid.	Not relevant. there is no way to know for sure; thus, there is no way to justify knowledge.
Evaluativists	Although everyone has their own opinion, some are considered to be more correct because they use better evidence.	Critical thinking skills are used to support judgments.

Individuals classified as *absolutists* made up the first category of epistemic beliefs. As in other models, individuals who are classified as absolutists had a high certainty about their beliefs and believed that some facts were the primary pieces of knowledge that should be known. Experts know these facts. *Multiplists* have developed their epistemic understanding over that of absolutists in such a way that allowed them the ability to accept the fact that other people may have different perspectives about knowledge. "Because claims are subjective opinions freely chosen by their holders and everyone has a right to their opinions, all opinions are equally right" (Kuhn, Cheney, & Weinstock, 2000, p. 310). Thus, the multiplist did not integrate the

perspectives of others into their own but, rather, allowed others to have their own opinions. In contrast, *Evaluativists* saw that although everyone had their own opinions, some opinions were considered to be more correct than others because they were supported by better arguments and evidence.

Methodological limitations of the epistemological thinking model. Although Kuhn (1991) describes her framework and the analysis used better than the work of most other researchers reviewed up to this point, there are still some limitations of this model. First, many researchers use Kuhn's model as a way to describe a person's epistemic beliefs. However, she actually described a person's reasoning skills and different types of reasoning that they use. These types of reasoning, though, have nothing to do with schooled knowledge. The topics Kuhn asked participants are not topics that would be used in classrooms. This is a major limitation in her work. Kuhn assumes her participants have knowledge, or at least a strong opinion, on the topics asked. No assessments of the knowledge of participants on these topics were completed. In addition, the only questions that were considered epistemic in nature ask participants about their knowledge in relation to the knowledge of experts. Participants may not be able to judge this if they know nothing of the topic.

Epistemological reflection model. Like King and Kitchener (1994) and Kuhn (1991), Baxter Magolda (1992) was also interested in students' beliefs as they relate to academic knowledge. Specifically, she was interested in the beliefs people have about knowledge, its certainty, and its limits. Baxter Magolda (1992) used responses of both college-age men and women to determine a unidimensional model of epistemic beliefs. Unlike Perry (1970) and Belenky et al. (1986), Baxter Magolda did not find gender differences in epistemic beliefs. Interviews were conducted with the respondents on an annual basis and the results were coded

according to the developmental schemes of Perry (1970) and Belenky et al. (1986). Baxter Magolda looked specifically at the role of learners, peers, and instructors in the learning process, as well as how learning should be evaluated by the instructor. In this case, evaluation did not mean justification, but rather it referred to assessment of knowledge. The nature of knowledge was also investigated.

Undergraduate participants (n=101) from Miami University of Ohio were asked a series of questions on their learning in the past year as well as how they preferred to learn. Some of the questions included the following: (a), "As you think about yourself as a learner in the classroom, what role do you prefer to play to make learning more effective for you?" (b), "As you think back over the work you've done in your classes the past year, think about how you think learning should be evaluated in order for you to learn effectively," or (c), "This past year you have probably heard and/or read a great deal of information. Usually with that amount of information, you run across some discrepancies. Has this happened to you?"

Grounded theory data analysis was used to analyze this data. Baxter Magolda states that the MER rating process, which was previously established, was used to analyze the data in this study. First, the researchers identified each of the participants' reasoning structures, which were considered to be reflective of the person's overall epistemic level. These were compared with the MER manual. If a match was not found, then a judgment was made as to whether the response reflected one of the epistemic levels. Reasoning structures of the participants were also analyzed.

Four epistemic beliefs were identified from the results of the interviews and questionnaires in what was named the Epistemological Reflection Model (ERM; Table 6). Like the work of Perry (1970) and Belenky et al. (1986), the model is developmental in nature; unlike

the previous work reviewed (Belenky et al., 1986, King & Kitchener, 1994; Kuhn, 1991; Perry, 1970), the model studies academic beliefs rather than beliefs that could occur in any situation.

Table 6

Epistemic Positions in Baxter Magolda's (1992) Epistemological Reflection Model

Epistemic Position	Description	Justification
Absolute Knowing	Knowledge is certain and absolute, and learners receive it from experts.	Authorities
Transitional Knowing	Knowledge has both certain and uncertain parts, and different people have different perspectives.	None is necessary because truths cannot be known.
Independent Knowing	All knowledge is uncertain because everyone has their own beliefs.	Integration of a person's own thoughts with their beliefs.
Contextual Knowing	All knowledge is uncertain, but some perspectives are more valid than others. All knowledge is contextual	Evidence collected in context.

The first belief framework in the ERM is *Absolute Knowing*. College students with this belief felt that knowledge is obtained specifically from the instructor and that the instructor's role was to "give" knowledge to the learners and make sure they understand it. Knowledge itself is seen as certain and absolute. This epistemic belief is approximately comparable to the first three stages of Perry's (1970) framework and Belenky et al.'s (1986) position of *received knowing*. Kuhn (1991) called these types of knowers *absolutists*.

Students who moved past *Absolute Knowing* developed into what Baxter Magolda termed as *Transitional Knowing*. In this belief framework, learners saw knowledge as having certain and

uncertain components. Unlike *Absolute Knowers*, where knowledge seen as uncertain was only labeled as such when the student did not know the answer, transitional knowers acknowledge varying perspectives. The role of a learner was to understand knowledge. This is decidedly different from the third epistemic belief position, *Independent Knowing*. Independent knowers viewed all knowledge as being uncertain because everyone has their own beliefs. An independent knower thinks for themselves and, through integrating their thoughts with their beliefs, creates their own perspective. People classified as independent knowers as well as those in the fourth epistemic position, *Contextual Knowing*, both viewed all knowledge as uncertain, but contextual knowers viewed some perspectives as being more valid than others. Specifically, knowledge was seen as contextual and was judged on the basis of evidence collected in the contexts. Learners integrated and applied their knowledge and were able to think through unique problems.

Methodological limitations of the epistemological reflection model. The grounded theory analysis used by Baxter Magolda is not well-described. Specifically, the same verbiage is used by Baxter Magolda to refer to a number of different concepts. Thus, it is difficult to understand exactly how her model of epistemic beliefs was developed. In addition, the MER rating process previously validated and used was not at all described. Thus, it is difficult to determine the type of analysis used. In addition, Baxter Magolda identifies that her sample is relatively homogeneous, calling into question the generalizability of the results.

Summary: Unidimensional Models

Much work has been done to develop the beginnings of what we know as the personal epistemology literature. A number of researchers have proposed models of epistemic beliefs that can be classified as unidimensional in nature. According to these models, individuals move

through different epistemic belief positions from naive to more sophisticated beliefs as they get older (e.g., King & Kitchener, 1994; Perry, 1970), or as they gain more experience in formal schooling (Belenky et al., 1986).

As can be seen in Table 1, a number of the positions in these epistemic belief models are similar across models. For example, in Perry's (1970) early work that served as the precursor to the personal epistemology literature, individuals evidencing different epistemic belief positions were labeled as *Dualists*, *Multiplists*, and *Relativists*. *Dualists* saw the world in a right-and-wrong manner. According to *Dualists*, authorities have the answers to all questions. This epistemic belief position is similar to a number of the naive epistemic belief positions of other researchers (e.g., *Received Knowledge*, Belenky et al., 1986; *Pre-Reflective Thinking*, King & Kitchener, 1994).

Similarly, Perry's (1970) conception of the next position along the epistemic continuum was that of *Multiplists. Multiplists* are those individuals who believed that truth exists for all questions in the same way as *Dualists*. Unlike *Dualists*, *Multiplists* recognized that answers have not yet been found for every question. Thus, because authorities do not yet have answers, justification for knowledge cannot happen because the perspectives of authorities are not trustworthy. This position is also similar to the belief positions of a number of other researchers' models (e.g., *Transitional Knowing*, Baxter Magolda, 1992; *Multiplist*, Kuhn, 1991).

Perry's (1970) final epistemic position comparable across many of the unidimensional models is that of the *Relativist*. According to *Relativists*, all individuals are entitled to have their own opinions. For *Relativists*, there are no right or wrong answers to issues because the issues are inaccessible and no correct answers exist. Again, these positions are similar to the

sophisticated beliefs in a number of other unidimensional models (e.g., *Contextual Knowledge*, Belenky et al., 1986; *Evaluativist*, Kuhn, 1991).

Multidimensional Systems of Epistemic Beliefs

According to some researchers (e.g., Schommer, 1990), one of the major problems with these models of epistemic beliefs is that there may be a number of different beliefs inherent within each of the epistemic positions identified. In addition, these different beliefs could develop at different rates. Thus, Schommer (1990) defined epistemic beliefs as consisting of a multidimensional system of beliefs.

Schommer's epistemological beliefs model. Marlene Schommer (now Schommer-Aikins) has taken a different approach to studying students' epistemic beliefs. She did not feel that a one-dimensional view of epistemic beliefs captured how students saw knowledge. Schommer (1990) proposed that students' epistemic belief frameworks comprised many different beliefs about knowledge that may or may not be all sophisticated beliefs. This multidimensional view of beliefs varied immensely from the traditional unidimensional conception Perry (1970) first promulgated. Perry's results showed that college students' beliefs about knowledge developed to be more sophisticated over time. Schommer, because she felt that students may have more than one belief about knowledge, thought that these beliefs might develop to become more sophisticated over time at different rates. Thus, the developmental nature of beliefs was not studied by Schommer in the same way that other, previous researchers had studied the development of beliefs (e.g., Baxter Magolda, 1992; King & Kitchener, 1994). Instead, Schommer and her colleagues concentrated on investigating both the factor structure of students' beliefs and their impact on diverse educational outcomes.

In her first test of a multidimensional structure to epistemic beliefs, Schommer (1990) wrote and validated a new assessment of those beliefs, the Schommer Epistemological Questionnaire (SEQ). Schommer (1990) hypothesized that university students' epistemic beliefs consisted of five dimensions: the structure, certainty, and source of knowledge, as well as the control and speed it takes to acquire knowledge. Participants for the first test of this instrument consisted of 117 junior college students and 149 university students who were enrolled in introductory psychology, educational psychology, or physics courses (Schommer, 1990). In order to test this framework, she created a 63-item questionnaire consisting of 12 subsets of items to assess the five hypothesized dimensions. Composite scores for each of the subscales were created for this analysis. Schommer (1990) used exploratory factor analysis techniques to analyze the factor structure of the twelve subsets of items. In her study, she found a factor structure with four identified beliefs about knowledge; *Innate Ability*, *Simple Knowledge*, *Quick Learning*, and *Certain Knowledge*. However, *Certain Knowledge* was only found to have one subset of items loading highly onto it. The hypothesized factor measuring *Omniscient Authority* did not emerge from the observed data. In her 1993 study, Schommer renamed the factor labeled *Innate Ability* as *Fixed Ability* because the subset of items assessing a belief in a person's innate ability loaded on the factor titled *Quick Learning*. Examples of items for each of these factors, as well as the subsets of items for each factor are given in Table 7.

Table 7

Items for Each of Schommer's (1990) Epistemic Belief Factors (Adapted from p. 500)

Epistemic Belief Factor	Subsets comprising belief dimensions	Sample items
Nature of Learning		
Innate Ability	Can't learn how to learn	Self help books are not much help.
	Success is unrelated to hard work.	The really smart students don't have to work hard to do well in school.
	Ability to learn is innate	An expert is someone who has a special gift in some area.
Quick Learning	Learning is quick	Successful students learn things quickly.
	Learn first time	Almost all the information you can learn from a textbook you will get during the first reading.
	Concentrated effort is a waste of time	If a person tries too hard to understand a problem, they will most likely just end up being confused.
Nature of Knowledge		
Simple Knowledge	Seek single answers	Most words have one clear meaning.
	Avoid integration	When I study I look for specific facts.
Certain Knowledge	Avoid ambiguity	I don't like movies that don't have an ending.
	Knowledge is certain	Scientists can ultimately get to the truth.
Omniscient Authority	Don't criticize authority	People who challenge authority are over-confident.
	Depend on authority	How much a person gets out of school depends on the teacher.

Schommer was also interested in testing her epistemic beliefs instrument with other populations. With a sample of adults (Schommer, 1998), the four factor structure was retained, with the only differences in the results being the percentage of variance explained by each of the factors and the fact that the percentage of variance explained by *Simple Knowledge* was greater than the amount explained by *Fixed Ability*. The beliefs of middle-school students, however, were different (Schommer-Aikins, Mau, Brookhart, & Hutter, 2000). When the 63-item questionnaire was given to seventh and eighth grade students, only three factors emerged from the data (i.e., *Speed of Learning*, *Ability to Learn*, and *Stability of Knowledge*).

Uses of Schommer's (1990) epistemological questionnaire. To date, Schommer's (1990, 1993) epistemic beliefs questionnaire is the most widely-used instrument for assessing epistemic beliefs. As a result, a number of researchers have used this instrument to investigate how epistemic beliefs influence and correlate with a number of different variables. One of the variables most widely studied is text comprehension. One of the first studies investigating the relations between epistemic beliefs and text was completed by Schommer and her colleagues (1992). They found that beliefs in *Simple Knowledge* were negatively associated with text comprehension. In other words, the more sophisticated the belief in *Simple Knowledge*, the greater the students' comprehension. Although the associations in this study were significant, they were not strong, which makes the results somewhat questionable. These results were paralleled and extended by Qian and Alvermann (1995). Using a refutational physics text, they found that high school students who held naïve beliefs about *Certain Knowledge* and *Quick Learning* were less likely to relinquish their naïve theories after reading the text.

Based on these results, other researchers (e.g., Kardash & Howell, 2000; Kardash & Scholes, 1996; Rukavina & Daneman, 1996) have used the subsets of Schommer's (1990, 1993)

instrument (Schommer et al., 1992; Qian & Alvermann, 1995) to determine which epistemic beliefs facilitate text comprehension. Kardash and Scholes (1996) found that those students with less certain beliefs about knowledge had less extreme initial beliefs referencing a dual-position text about the HIV-AIDS relationship. In addition, extreme positions about the text were less associated with authority beliefs (Kardash & Scholes, 1996). Undergraduates' differences in beliefs about the speed of knowledge acquisition and the effort it took to learn were influenced by the frequency of cognitive and strategic processes used to comprehend the same dual-positional text (Kardash & Howell, 2000).

In fact, students in high school and college with more mature epistemic beliefs performed better on measures of text comprehension (Rukavina & Daneman, 1996), which parallels the findings of Schommer and her colleagues (1992). To extend Schommer's work, Rukavina and Daneman (1996) investigated the influence of different types of text structures on the comprehension of students with different epistemic beliefs. Two types of text structures were given to participants. The first was an integrated text, where competing theories were presented in an integrated way within one longer text. In the separate text condition, participants read two texts each presenting one of the competing theories. Rukavina and Daneman (1996) found that students with immature epistemic beliefs benefited from having the integrated text, whereas the comprehension of the students with more mature epistemic beliefs was not affected by the structure of the text. In addition, Schommer (1990) found that epistemic beliefs affect the conclusions undergraduate students draw about text. Specifically, those students who were more likely to believe that learning is quick were also more likely to oversimplify conclusions about text. Those who believed that knowledge was certain wrote more absolute conclusions.

Evidence has also been shown that epistemic beliefs are related to other learning constructs. For example, participants in Braten and Stromso's (2005) study who held naïve epistemic beliefs were less likely to have high self-efficacy and were not as able to regulate their strategy use. Evidence has also shown that the more sophisticated students' epistemic beliefs are, the better their academic achievement (Cano, 2005, Conley et al., 2004; Schommer, 1993).

Changes in knowledge beliefs over time. Schommer (1990, 1993) advocated a multidimensional view of epistemic beliefs where different beliefs about knowledge may develop at different rates. Evidence of this has also been found by other researchers when using her questionnaire in their work. For example, Cano (2005) found that the epistemic beliefs of high school students change over time, as do their preferred approaches to learning. Jehng and his colleagues (1993) also found that graduate students were more likely than undergraduates to endorse beliefs that knowledge is uncertain, that learning is not an orderly process, and that independent learning is necessary. Although not all of these beliefs may be classified as being epistemic in nature, we can conclude from the findings that different beliefs about knowledge do develop at different rates. In fact, Schommer (1993) found evidence that students' beliefs about knowledge develop from their freshmen to senior years. Throughout adulthood, beliefs in the ability to learn change to be more sophisticated (Schommer, 1998). Beliefs in their simplicity and certainty of knowledge also become more sophisticated with an increase in education (Schommer, 1998).

Methodological limitations of the epistemological beliefs model. Although Schommer's instrument has been used in much of the research on epistemic beliefs, many researchers have identified a number of problems with its design and the analysis of the data collected from its use. Hofer and Pintrich (1997), in their extensive review of the literature on epistemic beliefs,

identified a number of problems with the instrument. The first set of problems deal with the analysis of the data resulting from use of the instrument. First, Schommer used the composite scores of the twelve subsets of items to model epistemic beliefs rather than analyze the data on an item-level basis. This raises doubts as to the nature of the factors identified. Second, no confirmatory factor analyses have been conducted with data collected using this instrument. Given the extensive amount of research using Schommer's instrument, the fact that researchers feel the factor structure is not stable enough to use confirmatory techniques is not promising in terms of the validity of the instrument. In addition, very little theoretical framework regarding the development of the instrument was provided by Schommer in any of her studies on epistemic beliefs.

A number of researchers have attempted unsuccessfully to replicate the factor structure of Schommer's (1990, 1993) instrument (e.g., Jehng et al., 1993; Qian & Alvermann, 1995) using proper exploratory factor analysis procedures. Qian and Alvermann (1995) found only three factors in Schommer's (1990, 1993) instrument: *Quick Learning*, *Innate Ability*, and *Simple/Certain Knowledge*. Jehng and his colleagues (1993) found that only 34 of the individual items loaded highly on one of Schommer's (1990) hypothesized belief factors.

In response to questions raised about the validity and factor structure of Schommer's (1990, 1993) instrument, other researchers have created measures of epistemic beliefs. Schraw and his colleagues (2002) took the criticisms of Schommer's multidimensional beliefs model and the analysis of factors within it into consideration when creating a new instrument. In response to these criticisms, Schraw and his colleagues created the Epistemic Belief Instrument (2002) in order to more directly and efficiently assess the factor structure identified and tested by Schommer (1990, 1993). Other instruments have been developed (e.g., Kuhn et al., 2000; Kuhn

& Weinstock, 2002), but the Epistemic Belief Instrument is the only one gaining popularity in the research (e.g., Ravindran, Greene, & DeBacker, 2005).

Other researchers have attempted to translate Schommer's instrument into other languages. This was done because it is important to study the epistemic beliefs of students in other countries because the nature of the cultures in those countries and the emphasis of their educational systems may lead to different epistemic belief structures than those of the students in the United States (Chan & Elliott, 2004a). For example, in a study by Clarebout and colleagues (2001), college sophomores took a Dutch translation of Schommer's (1990, 1993) instrument. However, the researchers found they were unable to replicate Schommer's factor structure. When a Spanish version of the instrument was used with secondary students (Cano, 2005), only the factors of *Quick Learning*, *Simple Knowledge*, and *Certain Knowledge* were identified. Braten and Stromso (2005) found four resultant factors in their use of a Norwegian version of the instrument (i.e., *Speed of Learning*, *Certain Knowledge*, *Knowledge Construction and Modification*, and *Control of Knowledge Acquisition*). However, Braten and Stromso (2005) used principle components analysis to determine their results. Even so, the results of these research studies put the factor structure of Schommer's (1990, 1993) instrument into question.

Summary: Epistemological Beliefs Model

The multidimensional model of epistemic beliefs proposed and researched extensively by Schommer (1990, 1993) and her colleagues (e.g., Schommer et al., 1992; Schommer & Dunnell, 1994) is one of the most widely-known and widely-used in the personal epistemology literature. Schommer (1990) proposed five dimensions for epistemic beliefs; those assessing the nature of knowledge (i.e., *Certain Knowledge*, *Simple Knowledge*, and *Omniscient Authority*), and those assessing the nature of learning (i.e., *Quick Learning* and *Innate Ability*). Of these five proposed

factors, all but *Omniscient Authority* were found consistently by Schommer to describe an individual's epistemic belief system.

Although Schommer's (1990) instrument is one of the most widely used in the personal epistemology literature, a number of problems have been identified with the validity of the instrument. Different groups of researchers (e.g., Jehng et al., 1993; Qian & Alvermann, 1995) have been unable to replicate Schommer's factor structure. In addition, researchers from other countries have translated Schommer's instrument into other languages (e.g., Braten & Stromso, 2005; Clarebout et al., 2001); yet, replication of the factor structure was unsuccessful.

Domain-Specific Beliefs

Domain differences using Schommer's (1990, 1993) epistemological questionnaire. As previously stated, the validity of the results of Schommer's instrument has been called into question by a number of researchers. This may be because epistemic beliefs should be conceptualized as domain-specific in nature (Buehl & Alexander, 2001). Thus, many researchers have used the instrument to investigate whether or not there are differences in epistemic beliefs depending upon the domain of specialty of the participants. This question is important because, "[I]f the instructional environments of disciplinary cultures either reinforce or influence students' epistemological beliefs, then a comparison of some of the characteristics [of the fields of study]…may provide a partial explanation of the observed differences in students' epistemological beliefs across these domains of study" (Paulsen & Wells, 1998, p. 376). That is, according to Paulsen and Wells (1998), people may choose their undergraduate majors based upon their epistemic beliefs, and those beliefs might be shaped by their experiences in those courses. Thus, researchers may find differences in epistemic beliefs based upon domain. A presentation of the content areas investigated is located in Table 8.

Table 8

Content Areas Investigated in the Domain-Specific Personal Epistemology Literature

	Text Comprehension	Science	Mathematics	History	Psychology
Studies investigating diverse content areas	Kardash & Howell (2000) Kardash & Scholes (1996) Rukavina & Daneman (1996) Schommer et al. (1992) Qian & Alvermann (1995)	Conley et al. (2004) Elby (n.d.) Hammer (1994) Hofer (2000) Tsai (1997) Tsai (2000)	Buehl et al. (2002) Higgins (1997) Schoenfeld (1983) Schoenfeld (1989) Wilkins & Brand (2004)	Buehl et al. (2002)	Hofer (2000)

When Paulsen and Wells (1998) looked at the epistemic beliefs of participants in fields classified along continuums of hard-soft and pure-applied according to Biglan's (1973a, 1973b, as cited in Paulsen & Wells, 1998) taxonomy, they found evidence of domain differences in *Simple Knowledge*, *Quick Learning*, and *Certain Knowledge*. Specifically, participants in soft and applied fields had more sophisticated beliefs than those in hard, pure fields, which were attributed to the nature of the domain and activities completed within that domain. This result was mirrored by Jehng and colleagues (1993). That is, participants in soft fields believe that knowledge is less certain and orderly than those in hard fields. Because of this, participants in soft fields felt they had to be more reliant on reasoning than those in hard fields. Braten and Stromso (2005) found similar results when studying the epistemic beliefs of teacher education students and those in a business management school. Specifically, those participants enrolled in teacher education programs were more likely to see knowledge as more able to be increased than those enrolled in business management programs.

Epistemic beliefs in science. Many of the researchers studying student's epistemic beliefs about one specific content use instruments to measure beliefs that have been defined only for use in that one content area. One of the content areas in which epistemic beliefs have been studied extensively is science (e.g., Conley et al., 2004; Hammer, 1994; Tsai, 1997, 2000). In interviews with college freshmen about their beliefs about physics, Hammer (1994) found that students ranged in their beliefs about the structure of the domain from foundational pieces to a coherent framework of knowledge. Although these beliefs sound very similar to the philosophical epistemic frameworks outlined previously, it must be noted that these beliefs are not about how knowledge is justified in physics. In addition, Elby (n.d.) has created a measure of epistemic beliefs about physical science, called the *Epistemological Beliefs Assessment for Physical*

Science for high school and college students enrolled in physical science courses. The instrument assessed five beliefs about physical science, *Structure of Scientific Knowledge*, *Nature of Knowing and Learning*, *Real-Life Applicability*, *Evolving Knowledge*, and *Source of Ability to Learn*.

In other studies of epistemic beliefs, Tsai (1997, 2000) defined epistemic beliefs, or *Scientific Epistemological Beliefs*, as being dependent on whether students had more empiricist beliefs or whether their beliefs were constructivist in nature using Pomeroy's (1993) questionnaire. He found that empiricists tended to stress the role of empirical evidence in their decisions, where constructivists felt that science was a dynamic content area. Specifically, "…when asked the sources of scientists' ideas, constructivists tended to believe that scientists' ideas came from their intuitions or flashes of insight…but *none* of them mentioned anything about observations" (Tsai, 1997, p. 478). This may be why constructivists felt that the learning environments they were exposed to in science classes did not offer them opportunities to learn or integrate their prior knowledge with class information (Tsai, 2000).

Conley and colleagues (2004) specifically addressed students' justification of knowledge in paper and pencil measures assessing beliefs about knowledge in science classrooms. Conley and her colleagues (2004) looked specifically at how fifth grade science students justified knowledge based upon responses to nine questions about the uses of science experiments in coming up with conclusions. For example, students were asked to rate such items as, "It is good to try experiments more than once to make sure of your findings," and, "Good answers are based on evidence from many different experiments." They found that children who were high achievers also had more sophisticated epistemic beliefs in science.

Domain-specific epistemic belief instruments. Other researchers (e.g., Buehl et al., 2002; Hofer, 2000) developed instruments to assess college students' epistemic beliefs in domain-specific ways. This was done by these researchers, in part, because epistemic beliefs had been assessed using mainly domain-general measures. Specifically, epistemic beliefs may be thought to be domain-general simply because "…the developmental model(s) inherent to most of the research conducted as well as an outcome of assessment instruments that were explicitly designed to tap more general beliefs" (Hofer, 2000, p. 379). Thus, Hofer concluded that epistemic beliefs were found to be domain-general simply as an artifact of the measurement system used to assess those beliefs.

Because many of the instruments constructed and used in research were designed to assess beliefs in a domain-general way, both Buehl et al. (2002) and Hofer (2000) set out to "ascertain whether students possess distinct epistemological beliefs depending on the academic domain under consideration" (Buehl et al., 2002, p. 416). Buehl and her colleagues also argued that because knowledge is multifaceted, beliefs about that knowledge must in turn be multifaceted, necessitating measures of epistemic beliefs that are domain-specific.

Although both Hofer (2000) and Buehl and her colleagues (2002) conceptualized that epistemic beliefs were both multidimensional and domain-specific in nature, they have studied them in different ways. Hofer's (2000) discipline-specific instrument will first be reviewed, followed by the domain-specific instrument conceptualized and developed by Buehl and her colleagues (2002).

In order to test the domain-specificity of beliefs, Hofer (2000) created a measure that assesses college students' beliefs in the disciplines of psychology and science. Specifically, 326 first year college students who were enrolled in an introductory psychology course participated

in the study. Participation was a required component of the course. The instrument to which they responded measured epistemic beliefs in a discipline-specific way. Some of the items on Hofer's (2000) measure were adapted from Schommer's (1990, 1993) epistemic belief questionnaire, and others were extrapolated from other work completed on epistemic beliefs (e.g., King & Kitchener, 1994; Kuhn, 1991; Perry, 1970). In addition, other items were written to reflect the four epistemic belief factors proposed by Hofer and Pintrich (1997). Each item in the questionnaire was written in a manner where the discipline being assessed was not given in the question; however, participants were asked to "keep a particular discipline in mind" (Hofer, 2000, p. 388) when responding to the items. The two disciplines about which participants were asked to think were psychology or science.

Results of the analysis showed that four factors of epistemic beliefs could be assessed (i.e., *Certain/Simple Knowledge*, *Justification for Knowing: Personal*, *Source of Knowledge: Authority*, and *Attainability of Truth*). In addition, participants responded to items assessing beliefs about psychology and science knowledge differently, suggesting that these individuals' beliefs were discipline-specific. Her results show that, indeed, beliefs assessed by her measures can be considered domain-specific in nature. In contrast to the results of Conley et al.'s (2004) study, Hofer (2000) found that undergraduates prefer to justify their views based upon "...personal opinion and firsthand experience over research or evaluated expertise (e.g., "I am more likely to accept the ideas of someone with firsthand experience than the ideas of researchers in this field")" (p. 398).

Buehl and her colleagues (2002) also created a domain-specific epistemic beliefs questionnaire (DSBQ) to assess college students' beliefs about history and mathematics. Like Hofer (2002), Buehl used Schommer's (1990) epistemic beliefs questionnaire to begin to write

items for her assessment. Undergraduate participants (study 2: N = 633; study 3: N = 523) responded a final, 50-item questionnaire. Unlike with Hofer's (2000) instrument, the items on the questionnaire specifically mentioned the domain they were designed to assess. In addition, parallel items were written for both history and mathematics, with twelve items being reverse coded.

Buehl and her colleagues (2002) found that 22 items from the full measure loaded highly onto one of four factors. These factors assessed beliefs about the *Integration of Information and Problem Solving* and *Need for Effort*. In addition, domain-specific beliefs were evidenced in the data. Both the *Integration of Information and Problem Solving* and *Need for Effort* factors were differentiated by history and mathematics, for a total of four factors.

Unlike Hofer's (2002) discipline-specific instrument, Buehl's domain-specific instrument has been used with middle school students to investigate the dimensionality and domain-specificity of their beliefs (Murphy et al., in press). Through a series of studies, Buehl, Murphy, and their colleagues (e.g., Murphy et al., in press; Buehl, Edwards, & Murphy, submitted) found that eighth and ninth grade students did not show evidence of domain-specificity in their beliefs. However, results showed that as students progress from eighth to ninth grade, the dimensionality of their beliefs about knowledge changed from being unidimensional to differentiating beliefs about the importance of hard work (Murphy et al., in press). Little work, however, has been done with Hofer's discipline-specific instrument outside of studies by the author.

Summary: Models of Domain-Specific Beliefs

Much work has been completed to investigate the domain-specific nature of epistemic beliefs. Work has been completed using Schommer's (1990, 1993) instrument to investigate beliefs in a domain-specific way (e.g., Jehng et al., 1993). In addition, a number of studies have

been completed in science areas (e.g., Conley et al., 2004; Tsai, 1997, 2000) and across domains (e.g., Buehl et. al., 2002; Hofer, 2000). With the exception of the instruments created by Buehl and her colleagues (2002) and Hofer (2000), most studies of domain-specific beliefs do not compare beliefs across domains. In addition, only one study (e.g., Schommer & Walker, 1995) compares beliefs that are domain-general and domain-specific. Thus, it appears that the investigation of domain-specific beliefs is an area of research where more work is needed.

Conflicts Within and Limitations of the Psychological Epistemology Literature

Unidimensional versus multidimensional beliefs. Early in epistemic belief research, researchers were interested in finding what appeared to be the "one belief" people had about knowledge. Perry (1970), Baxter Magolda (1992), and many other researchers combined all of students' beliefs about knowledge into what amounted to profiles of knowledge beliefs. Evidence was given by these researchers of multiple profiles of epistemic beliefs. In addition, individuals developed into having different profiles over time, but only one belief about knowledge was found by these researchers.

With the exception of Kuhn and her colleagues (1991, Kuhn et al., 2000), researchers who were interested in developing profiles of epistemic beliefs using a unidimensional framework used qualitative methods for data collection consisting of interviews over long periods of time, primarily at key points in participants' lives. Data from these interviews were compiled to create intricate profiles of students' knowledge beliefs.

However, researchers like Schommer and her colleagues (1990, 1993, Schommer et al., 1992) thought that not only did this type of data collection take too long to do to identify participants' epistemic beliefs, but that epistemic beliefs were better measured by a

multidimensional system of beliefs rather than just one overarching belief. Thus, Schommer proposed that five beliefs about knowledge made up the set of epistemic beliefs.

Other researchers have followed closely in Schommer's footsteps. Many researchers (e.g., Jehng et al., 1993; Qian & Alvermann, 1995) were interested in determining whether or not Schommer's factor structure was appropriate, and Schommer herself tested her factor structure for new populations (Schommer, 1998; Schommer-Aikins et al., 2000). Other researchers have questioned whether or not Schommer's factor structure is appropriate because of problems with her data analysis techniques (Hofer & Pintrich, 1997). Still other researchers have tried to write instruments better reflecting Schommer's multidimensional factor structure (Schraw et al., 2002).

It is promising to see that researchers have begun to look at individuals' beliefs about knowledge justification (e.g., Conley et al., 2004; Hofer, 2000). However, this research does not assess the justification of knowledge by looking at the underlying philosophical beliefs to which individuals hold. Indeed, Buehl and Alexander (2001) are correct in stating that "…when researchers describe their work, the philosophical bases for what makes the beliefs epistemological are rarely articulated" (p. 387). Clearly, there is need for an epistemic beliefs measure that not only takes views about the justification condition into account, but connects those views with philosophical definitions of what it means for knowledge to be justified.

Domain-general versus domain-specific beliefs. Another issue concerning epistemic beliefs researchers is whether or not beliefs are domain-general in nature or whether they are more specific within each domain. The study of epistemic beliefs started with Perry (1970) concluding that beliefs about knowledge were domain-general and developed over time from *dualistic* to *multiplistic* to *relativistic* beliefs. However, this belief was measured without respect

to domain. That is, Perry felt that beliefs about knowledge did not vary with the content being used. Other researchers followed along this same line. Belenky and her colleagues (1986) studied women's beliefs about knowledge. They studied women from varied backgrounds and having a variety of educational opportunities and interests. They also found evidence of one overall belief that develops over time that is irrespective of the domain of knowledge. More recently, Kuhn and her colleagues (Kuhn et al., 2000) found similar results; there is one belief about all knowledge, regardless of the content being studied.

It was not until Schommer's work that multiple beliefs about knowledge began to appear in the literature (1990, 1993). For much of her research, Schommer and her colleagues (1990, 1992; Schommer-Aikins et al., 2000) studied domain-general beliefs about knowledge, as did other groups of researchers, such as Schraw and his colleagues (2002). Unlike earlier researchers studying epistemic beliefs, Schommer, (1990, 1993), Kuhn and her colleagues (2000), and Schraw et al. (2002) developed surveys to measure domain-general epistemic beliefs. These researchers found a variety of different factors, and sometimes found different factors in different studies (e.g., Schommer, 1990, 1993, 1998). However, one commonality between all these areas of research is that these domain-general factors measured by the instruments account for a significant amount of variance in students' beliefs. This leads us to the conclusion that students' beliefs about knowledge have a domain-general character when measured using an instrument that is not content-specific.

Other researchers have been more interested in students' epistemic beliefs about certain content areas. For example, Hammer (1994) was interested in identifying students' epistemic beliefs in the content of physics. He found specific beliefs about physics knowledge are relevant for their understanding. Higgins (1997) and Schoenfeld (1983, 1989) were more interested in

studying students' beliefs about mathematics, and found that their epistemic beliefs influenced their performance in that content area. Rukavina and Daneman (1996) found evidence that epistemic beliefs about controversial science theories affect students' abilities to comprehend different kinds of text. Cobern (2000) and Conley and her colleagues (2004) both were interested in studying students' beliefs about science content.

Other researchers, such as Buehl et al. (2002) and Hofer (2000) developed measures to assess students' varying beliefs about different educational content. Buehl and her colleagues (2002) developed the *Domain-Specific Beliefs Questionnaire* specifically to assess students' belief about the nature of knowledge in the well-structured domain of mathematics and the ill-structured domain of history. These specific content areas were identified for analysis because it was thought that students may have differing beliefs about content that may be structured and taught in different ways. Hofer (2000) studied epistemic beliefs in a similar way by creating instruments measuring students' discipline-specific beliefs about psychology and mathematics. Again, the premise behind the creation of her instrument is the same as that of Buehl and her colleagues. Specifically, if students are exposed to content structured and taught in different ways, they are likely to have varying beliefs about that content. The results of Buehl et al. (2002) and Hofer (2000) are similar to those found by researchers measuring more domain-general beliefs. That is, factors found in domain-specific instruments account for variance in student beliefs.

Although much work has been completed on domain-generality and domain-specificity of epistemic beliefs separately, very little research has been conducted to determine *which* type of belief is accurate. Schommer and Walker (1995) completed a study where they were interested in determining whether epistemic beliefs were in fact domain-general or whether they

were more content specific in nature. These researchers gave Schommer's questionnaire (1990, 1993) in the way written but with asking participants to think of a specific domain when answering, and then also had students respond to questions on the assessment with reminders of the specific domain. The researchers found great similarity in the way participants answered questions when thinking about different content areas. They also found that much of the results for one domain were predicted by beliefs about the other domain, and thus argued that the study showed a domain-independent flavor in epistemic beliefs.

Although Schommer and Walker's (1995) research seems to present strong evidence for a domain-general view of epistemic beliefs, the study is wrought with methodological concerns. For example, the domains tested (i.e., mathematics and social sciences) were not parallel. In addition, modifications were made to an existing instrument assessing domain-general beliefs. Although Schommer and Walker (1995) concluded that beliefs were primarily domain-general in nature, these methodological concerns raise doubts about that conclusion.

Teachers' Epistemic Beliefs and Pedagogical Practices

As can be seen, a number of conflicts exist within the personal epistemology literature. Another area that has lacked attention and resolution in this literature is the investigation of teachers' epistemic beliefs.

The Importance of Studying Teachers' Beliefs

Much of the research previously identified and reviewed investigated the beliefs of students, particularly at the undergraduate level. Very few of the studies reviewed have investigated the epistemic beliefs of preservice teachers (e.g., Braten & Stromso, 2005; Ravindran et al., 2005). However, it is important to study the epistemic beliefs of teachers because "many of the disabling epistemic beliefs that students have by high school have come

from the way in which they have been taught" (Schommer, 1990, pp. 503-504). In his commentary to a special issue on epistemic beliefs published in 2001, Schraw wrote about on the need researchers have to gain a better understanding of what kind of epistemic beliefs experienced and novice teachers have, how their epistemic beliefs change, and how they affect student learning (p. 461). This same sentiment was echoed by Hofer (2001) in her review of the literature

Ravindran and colleagues (2005) attempted to address Schraw's (2001) concern. In their study, they found that preservice teachers who had naïve beliefs about authority did not report engaging with their course materials in as meaningful a way as did those preservice teachers with more sophisticated beliefs. Ravindran et al. (2005) concluded that if course materials are not used properly when the preservice teachers are learning how to teach, it is questionable whether they will use them in meaningful ways when they are teaching.

Research has shown that preservice teachers can be taught to change their epistemic beliefs (see also Valanides & Angeli, 2005). In a study by Wilkins and Brand (2004), elementary preservice teachers were taught specifically beliefs about effective mathematics instruction adhering to National Council of Teachers of Mathematics standards (2000) were able to change their beliefs in such a way that they were more in line with NCTM practices. Wilkins and Brand (2004), however, acknowledged that these beliefs were not tested in classrooms, and gains could decrease after the preservice teachers gain classroom experiences. This may happen because preservice teachers have "fragile knowledge" about teaching (Nesbitt Vacc & Bright, 1999). Their lack of experience may render them unable to use the teaching techniques they believe to be valuable in the classroom (Nesbitt Vacc & Bright, 1999).

However, explicitly teaching and assessing preservice teachers' epistemic beliefs is important. One way this can be done is to allow preservice teachers to opportunity to reflect explicitly on their epistemic beliefs (Brownlee, Purdie, & Boulton-Lewis, 2001; Nesbitt Vacc & Bright, 1999). This is important because teachers' epistemic beliefs "…have been found to affect teachers' use of teaching strategies and their openness to student alternative conceptions" (Hashweh, 1996, as cited by Chan & Elliott, 2004b, p. 818). When preservice teachers are provided with the opportunity to think extensively about their epistemic beliefs in interviews, they have more sophisticated beliefs about the speed of learning and the certainty of knowledge than do preservice teachers who are not questioned extensively about their epistemic beliefs.

Little work has been done to determine how epistemic beliefs affect teachers' practices. In a study conducted in Hong Kong, Chan & Elliott (2004b) found that traditional notions of teaching were positively related to teachers' naïve beliefs about students' innate ability, authority, and the certainty of knowledge. Those teachers using more constructivist teaching practices felt that knowledge is gained through effort and that knowledge was not certain. However, the study did not link epistemic beliefs to specific pedagogical practices, but to a framework for teaching.

Effective Pedagogical Frameworks

Although these studies begin to look at *teacher epistemic beliefs*, they do not connect their beliefs to their pedagogical practices. This connection is important because it is the practices of the teacher that will influence students' beliefs (Hofer, 2001). Yet, very few researchers even address how students' beliefs may be affected by teachers' pedagogical practices. For example, according to Cano (2005),

> ....as far as course planning is concerned, it is necessary to take into account not only students' previous knowledge and learning strategies (Weinstein & Mayer, 1986), but also their learning approaches and epistemological beliefs....to try to enhance the depth of learning approaches and the complexity of epistemological beliefs, as a way of improving academic achievement. (p. 217)

However, if teachers employed instructional methods that directly addressed their beliefs, students might use what they have learned and might also be able to identify beliefs that may be counterproductive (Hammer, 1994).

In looking to the literature on pedagogical practices, a number of instructional frameworks have been identified as being effective in classrooms, and possibly being effective to changing students' beliefs. Three of these types of effective pedagogical practices (i.e., traditional pedagogical practices, constructivism, and persuasive pedagogy) will be reviewed.

Traditional teaching practices. When teachers choose the pedagogical practices they will employ in their classrooms, their main goal is student learning. However, a number of different types of pedagogical practices can meet these goals. Often, teachers choose to adopt practices that would be considered traditional in nature. In their review, Tschannen-Moran, Woolfolk Hoy, and Hoy (1998), attempted to bring clarity to the teacher efficacy literature and, in turn, to the instruments assessing this construct. Inherent in these instruments are operationalizations of traditional teaching practices that are generally accepted as being effective (Edwards et al., 2007). It should be stated that although these practices are described as being traditional in nature, they are seen as important in all good teaching.

After a thorough review of the literature, Tschannen-Moran and Woolfolk Hoy (2001) created a new instrument assessing teacher efficacy. In this measure were categories of items

describing traditional teaching practices. The first of these categories consisted of teachers' instructional strategies, or their practices that are designed to increase student learning. Some of these practices included the teacher's abilities to use a variety of assessments, craft meaningful questions, adjust lessons to an appropriate level for the students, and to gauge students' comprehension.

The second of these categories of practices addressed teachers' classroom management practices. On their measure, Tschannen-Moran and Woolfolk Hoy (2001), operationally defined teachers' classroom management as consisting of strategies used for increasing the positive influences in a classroom, such as praise, encouragement and attention. In addition, strategies for reducing negative behavior, such as using punishments or reprimands, are operationally defined in the teacher efficacy literature.

The final category of traditionally accepted teaching practices as operationalized on the Tschannen-Moran and Woolfolk Hoy (2001) measure consisted of practices that teachers would employ to keep students engaged. In these items, teachers were asked about their practices to help students value learning, helping students think critically, improve the understandings of students who are not doing well, and motivating students who show low interest.

As stated previously, these practices were identified and accepted by educators as being valuable regardless of the content area or age-level of the students (Edwards et al., 2007). However, these traditional practices neglect much of what may be important to educators. Thus, a number of different paradigms of instruction have been forwarded to add to the concept of teaching practices.

Constructivism. A leading paradigm that is becoming more popular recently, especially in mathematics education (e.g., Simon, 1995) is called constructivism. In contrast to what can be

thought of as rote memorization, constructivists feel that knowledge cannot be transmitted from one person to the next in the same form as the first person originally held it. Instead, knowledge is seen as the ordering and organization of a person's world as seen through their own eyes or experiences (von Glaserfeld, 1991). As such, knowledge must be constructed on an individual basis because all people have different experiences. Learning for constructivists, then, happens as a result of active participation by which an individual interprets their new experiences in light of their previous experiences (Cobb & Steffe, 1983). If learning, then, happens as constructivist say it does, their teaching practices would be considerably different from the practices found in more traditional classrooms.

Unfortunately, constructivists do not set forth a descriptive or prescriptive set of guidelines that teachers should follow in order to be considered a constructivist. Indeed, Simon (1995) stated that once constructivism is operationalized, the teaching practice loses its individual nature and can no longer be considered constructivism (see also Bauersfeld, 1995).

Although it is not possible to set out a definitive set of teaching practices comprising constructivist pedagogy according to the theory, some general characteristics must be present for the pedagogy to be constructivist in nature. First, teachers must thoughtfully design learning situations in which learners can interact with concepts (Steffe & Kieren, 1994). These activities allow students the opportunity to interact with the concepts and, possibly, with others in the classroom. Second, dialogue about ideas, in forms of constructivism that are social rather than radical, should occur in a classroom because of the nature for the learning environment found in schools. Third, Simon (1995) and Steff and Ambrosia (1995) state that constructivist teaching is characterized by reflective inquiry, whereby both students and teachers reflect upon and discuss their understandings in order to promote knowledge construction.

This is not to say that constructivism in any way mirrors what is known as "discovery learning." In discovery learning, students are left completely to their own devices to learn whatever it is they happen upon. Instead, constructivism promotes much more well-structured and organized activities so that students construct new knowledge that may align with scientifically-held understandings.

Thus, a number of pedagogical practices can be implied based on knowledge of the constructivist paradigm (Higley & Edwards, 2006). First, teachers should have clear goals and a rationale for all their teaching decisions so that their pedagogy does not become discovery learning. Second, teachers should design learning activities that allow students to formulate and test new understandings. Simon (1995) states that good pedagogy requires teachers to infer student knowledge based upon their interactions with students, and develop hypothetical learning trajectories for each student in order to plan lessons to help them move their understandings forward.

Most importantly, however, constructivist teaching is characterized by asking the student to take responsibility for learning. Students are given ownership of problems, ideas, and solutions to their problems. This is similar to what is known in the discussion literature as "interpretive-authority" (Chinn, Anderson, & Waggoner, 2001), where students are given ownership of deciding what a text means. Teaching practices that give evidence of this interpretive authority in constructivist teaching are discussion about problems, and reflection by both the teacher and the student about their understanding and how they came up with their new understanding.

Although allowing students to have interpretive authority and construct their knowledge based upon prior understandings sounds like wonderful pedagogy, there are some limitations to

constructivism. First, there are no specific pedagogical practices that comprise this pedagogy. Although this makes theoretical sense, it becomes a problem because teaches may not know the types of practices it takes to achieve these goals. Second, the construction of knowledge relies heavily on students' prior understandings. If students have misconceptions, they may build upon those misconceptions when constructing new understandings, thus entrenching the misconceptions even more. In addition, students may confuse knowledge with beliefs and may construct what they feel is new knowledge upon previously help beliefs that may not be scientific in nature (e.g., Vosniadou & Brewer, 1992). Because constructivism offers no specific practices to teachers, it also offers no recourse for when these types of problems occur (Higley & Edwards, 2006).

Finally, neither the epistemic beliefs of students or teachers are taken into account in constructivism. Specifically, although the discussion of ideas is encouraged in forms of social constructivism (Cobb, 1995), no mention of the use of supporting evidence is given. In other words, discussion is encouraged in constructivism, but it is unclear as to whether students are required to support their ideas with evidence during discussions. In addition, because no specific pedagogical practices are forwarded, there is no discussion in the constructivist literature about what types of evidence should be considered viable.

This problem is even more pervasive in more radical forms of constructivism. Radical constructivists believe that it is impossible for people to even communicate or understand each other because they do not share any knowledge. They have different experiences upon which knowledge is based. Thus, providing evidence for one's ideas is not possible because knowledge only comes through personal experiences which cannot be shared. This, however, presents a problem for teachers who are trying to help their student gain knowledge. Specifically, not even

teachers can determine what a student knows, and the student is unable to give the teacher any direct evidence of their knowledge because they do not share the personal experiences upon which the knowledge is built.

Two researchers studying epistemic beliefs have looked at constructivist teaching practices and how they affect students' beliefs. Brownlee and her colleagues (2001) used Schommer's (1990) instrument to investigate the epistemic beliefs of preservice teachers. They found that these teachers believed constructivist practices could help their students develop more sophisticated beliefs. Tsai (1998) found something similar; specifically, students who felt their responsibilities as students were to construct new knowledge had more sophisticated epistemic beliefs than those who did not believe constructivist learning was their role in classrooms.

Persuasive pedagogical practices. In contrast to the implicit understandings and construction of knowledge evident in constructivist teaching stands persuasive pedagogy (Higley & Edwards, 2006). Persuasive pedagogical practices are those practices highlighted in the literature on Teaching as Persuasion (Murphy, 2001). The use of these practices helps students to make their implicit understandings explicit so that their viability can be judged by teachers and other students.

As with constructivist forms of teaching, persuasive pedagogy does not endorse the idea that teaching consists of the transmission of correct knowledge to a student (Murphy, 2001). Rather, the Teaching as Persuasion (Fives & Alexander, 2001) paradigm involves the evaluation of students' prior knowledge and beliefs through reason, evidence, and justification. In Teaching as Persuasion, a teacher's primary role is to help students make their understandings explicit in order to expose, challenge and correct misconceptions.

Researchers studying Teaching as Persuasion offer a number of specific practices to teachers to help facilitate their students' understandings. In all these practices, three conditions must be met in order to consider teaching as being persuasive (Murphy, 2001). First, teachers must recognize individual student characteristics of their knowledge, beliefs, and interests, and take these into account when designing instructional activities. Second, teachers must have clear goals in mind and design their instruction to meet these goals, while also choosing a text, problem, or context to purposefully meet these goals. Finally, students must also understand the persuasive process and what it means to be persuasive. They must be taught to recognize the persuasive influences of messages, and also how to be persuasive with their own understandings.

In order to help their students both be persuasive and make their knowledge explicit, persuasive pedagogy (Alexander, 2005) emphasizes the use of evidence and justification by all members of the classroom. In order to do this, a number of practices are forwarded by researchers:

- Assess students' initial understandings and beliefs (Alexander, Fives, Buehl, & Mulhern, 2002; Stevens & Fives, 2005)
- Refine insufficient background knowledge using student experiences (Buehl, Manning, Cox, & Fives, 2005)
- Instruct students in the persuasion process (Chinn & Samarapungavan, 2001; Hynd, 2001)
- Incorporate students' views in a lesson (Alexander et al., 2002)
- Connect instruction to students' motivation and emotions (Stevens & Fives, 2005)
- Encourage and consider alternative perspectives (Alexander et al., 2002)
- Seek confirming evidence from students for their positions (Fives & Alexander, 2001)

- Analyze the credibility of sources (Alexander et al., 2002)
- Recognize multiple sources of authority (Fives & Alexander, 2001)
- Encourage students to identify problems in arguments (Buehl et al., 2005)

The use of persuasive pedagogical practices has been shown to increase student understandings (Alexander et al., 2002). Alexander and her colleagues (2002) found that when students were exposed to persuasive pedagogical practices, they were able to modify both their knowledge and beliefs. Students also evidenced changes in beliefs when exposed to high-quality lessons using persuasive practices in an online format (Stevens & Fives, 2005).

There are some limitations within the persuasive pedagogy literature. First, studies completed with preservice teachers only ask participants to rate their beliefs about different practices comprising persuasive pedagogy (Edwards et al., 2007; Sinatra & Kardash, 2004). These studies do not investigate those teachers' demonstrated use of persuasive practices.

In addition, although the use of persuasive practices have been shown to increase students' understandings (Fives & Alexander, 2001), it is not clear exactly *what* about the pedagogy helped to increase understandings. Specifically, students were asked through persuasive pedagogical practices to provide evidence for their knowledge, but no description is given of how students were taught to provide evidence in the Teaching as Persuasion literature. In other words there is no indication in this literature of what is accepted as good evidence of understandings. Therefore, teachers are left to their own devices to determine whether or not a student is providing evidence of their understanding. This is a significant problem in the Teaching as Persuasion literature.

The same problem persists in other research studies where students are asked or required to provide evidence for their understandings. A number of articles were found investigating how

students develop understandings of presenting evidence for their claims in well-structured domains (e.g., Brickhouse, Dagher, Letts, & Shipman, 2000; Lampert, 1990; Ying, 2004). Specifically, students were only able to provide the types of evidence they were explicitly taught to provide. They were not taught what types of evidence were viable, or how to distinguish among different types of evidence or reasoning.

This point is also missing from the persuasive pedagogy literature. Researchers and theorists state that evidence is important and should be given by students. By using persuasive practices, teachers instruct their students to provide evidence for their claims. However, there is no indication of how to teach students to distinguish among types of evidence or to determine which types of evidence are more useful or valuable.

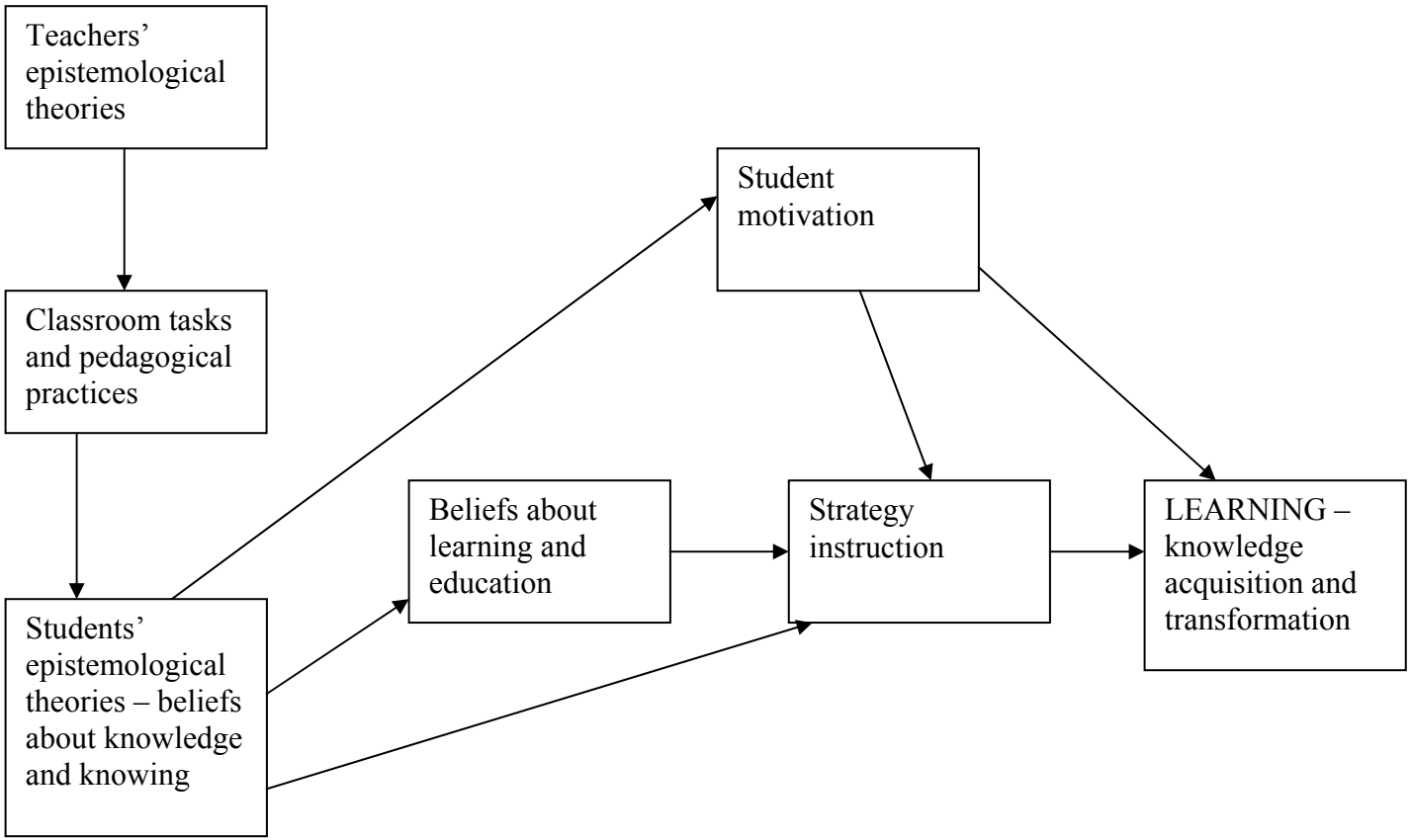
Although these practices may affect students' beliefs, there is little in the literature looking at how these practices stem from teachers' beliefs. Schraw (2001) identified the lack of literature on teachers' epistemic beliefs as being one area where researchers should begin to focus their study. He stated that, "[a]ssuming that teachers' beliefs do affect students, questions arise whether teachers should actively discuss their beliefs with students in an attempt to promote conceptual change" (p. 461). Thus, teachers' beliefs may affect what they do in their classrooms and the pedagogical practices they employ. These beliefs may also affect what types of evidence they will consider as viable from their students.

According to Hofer in her 2001 review of the literature, there is little research "that clarifies the relation between methods and types of instruction and personal epistemology" (p. 378). In her working model on how epistemic theories influence classroom practices, Hofer (2001) identifies that teachers' epistemic beliefs influence their classroom practices, which in

turn influences student' epistemic beliefs (see Figure 1). These beliefs, in turn, can affect other educational variables.

Figure 1.

Hofer's (2001, p. 372) working model of how epistemological theories influence classroom learning



Summary

A number of models of epistemic beliefs have been forwarded in the literature. Beginning with models assessing beliefs in a unidimensional way (e.g., King & Kitchener, 1994; Perry, 1970), researchers felt that individuals developed their beliefs from being naive to sophisticated in a continuum. Other researchers (e.g., Schommer, 1990, 1993) studied beliefs in a multidimensional way, stating that epistemic beliefs consist of a number of belief dimensions. Some researchers have investigated these multidimensional epistemic belief structures in a domain-general way (e.g., Ravindran et al., 2005; Schommer, 1998). Others have investigated epistemic beliefs one content area, such as science (e.g., Conley et al., 2004; Hammer, 1994), or text comprehension (e.g., Kardash & Howell, 2000; Qian & Alvermann, 1995; Rukavina & Daneman, 1996), or across multiple content areas (e.g., Buehl et al., 2002; Hofer, 2000).

Although much research has been completed to investigate epistemic beliefs, there exist a number of holes in the literature. First, a number of methodological limitations exist for each of the studies. Specifically, descriptions of qualitative analyses are vague or confusing (e.g., Baxter Magolda, 1992), or incorrect analyses procedures are used (e.g., Schommer, 1990; 1993; Schommer et al., 1992). These methodological limitations were described in this literature review. In this dissertation study, a new instrument was created paying special attention to the validity and reliability of scores. The stability of scores for the new instrument will also be investigated in this dissertation study, as scores of other personal epistemology instruments were rarely stable.

In addition, definitions of the construct of epistemic beliefs vary depending upon the study under review. Although most researchers define epistemic beliefs as being about "the nature of knowledge and knowing" (Buehl et al., 2002; Chan & Elliott, 2004a; Conley et al.,

2004; Duell & Schommer-Aikins, 2001), this definition is conceptualized differently in many studies. However, what is missing from all conceptualizations of epistemic beliefs in the literature is the conceptualizations of epistemic beliefs that are forwarded in the philosophical literature on epistemology. The epistemological frameworks of *foundationalism*, *coherentism*, and *reliabilism* were reviewed in this chapter. In order to begin to investigate these frameworks in the personal epistemology literature, the new instrument created for this dissertation study used these three frameworks from the philosophical literature.

The third limitation in the personal epistemology literature is the fact that teacher epistemic beliefs are rarely studied. In addition, the connection between teachers' beliefs and their pedagogical practices are not addressed in this literature. Thus, this dissertation study is a first step in assessing teacher epistemic beliefs as they relate to their choices of pedagogical practices.

CHAPTER 3

METHODS

The purpose of this dissertation study was to develop and begin to establish the reliability and validity of scores for a new instrument designed to measure *teacher epistemic beliefs*. In this study, *teacher epistemic beliefs* are defined as those beliefs teachers have about what it means for students to know something and how students best acquire this knowledge as evidenced in the pedagogical practices they use. In order to assess the reliability and convergent validity of the instrument's scores, a number of research questions were addressed.

1. *Reliability*
    a. To what extent are teacher epistemic frame profiles consistent across item type and within selected pedagogical practices?
        i. To what degree can belief profiles be identified for Likert-type items?
        ii. To what degree can belief profiles be identified for each epistemic framework across science content areas in the rank-scaled items?
        iii. To what degree can descriptions of lessons given on constructed-response items be rated similarly by independent raters?
    b. To what extent does the instrument produce internally consistent scores to assess *teacher epistemic beliefs* as measured by the Likert-type items?
    c. To what extent does the instrument provide stable scores of *teacher epistemic beliefs* as measured by the Likert-type and rank-scaled items?
2. *Convergent Validity*
    a. To what extent do teachers' reported epistemic frame scores relate to one another?

b. To what degree are the responses of the various measures developed in this instrumentation system related to one another?
c. To what extent do teachers' reported epistemic beliefs correlate with their personal epistemology?

In order to assess these questions, samples of both preservice and inservice teachers were collected. An instrument with three different types of questions was developed. The samples and the instrument are described below, followed by a description of the procedures for data collection.

Participants

Participants for this study were solicited from two groups, preservice and inservice elementary teachers. A sample of preservice elementary teachers who are currently interns in a suburban Mid-Atlantic school district, completing a year-long student teaching assignment in conjunction with a Professional Development School (PDS), were considered for participation. There are 61 interns enrolled in this program, and all were asked to participate in this study. Of the interns, 54 chose to participate in the study at least once and had usable data, with 16 of them participating at all three time points with usable data. Unusable data were collected from twelve participants for at least one time point. Unusable data consisted of data where participants may not have completed the questionnaire (e.g., one page was left blank), or where the participants showed evidence of a response set. For example, one of the participants rated all Likert-type items except for one as being *very useful* in their teaching. Data from this intern was not considered viable. Participating interns taught a variety of grade levels from Kindergarten to fifth grade, and had 21.7 students in their class on average. The majority of participants were female

(96.3%), with only two males participating in the study. Similarly, 96.3%, or 52 participants were Caucasian.

The second group of individuals from whom participation was solicited were the mentor teachers working with the interns. These teachers were the inservice teachers in whose classrooms the preservice teachers worked. It is important that not only preservice teachers participate in this study. Inservice teachers have more well-developed and established beliefs about what constitutes evidence of student learning based upon their years of experience as teachers (Nesbitt Vacc & Bright, 1999). The preservice interns are just beginning to gain this experience. There are the same number of inservice elementary teachers working with the PDS as there are preservice interns (N = 61), and all were asked to participate in this study. Of those mentor teachers twelve participated in the study at the first data collection time. At a second data collection point, six inservice teachers participated in the study. However, only one teacher participated at both time points. Thus, the second set of data collected from this teacher was dropped and the data from the 17 participants were combined for analyses. All participating inservice teachers were female and Caucasian.

Instrumentation

Purpose

A new instrument for assessing *teacher epistemic beliefs* was created and the reliability and validity of its scores was investigated in this dissertation. This was done in order to determine whether or not preservice and inservice elementary teachers consistently evidenced the same epistemic profiles in their pedagogical practices or whether they do not. With the exception of very few studies (e.g., Braten & Stromso, 2005; Nesbitt Vacc & Bright, 1999; Wilkins & Brand, 2004), the epistemic beliefs of teachers are generally not studied. In addition,

there are no instruments in the current literature for which stable estimates of beliefs exist (e.g., Jehng et al., 1993; Qian & Alvermann, 1995). Thus, the purpose of this study was to create an instrument providing valid and reliable estimates of the epistemic beliefs of teachers. In order to do this, an instrument was created around the philosophical definitions of epistemic beliefs describing the conditions under which knowledge is justified.

Instrument Development

A number of epistemological frameworks that can be used to promote conceptual change have been identified (Murphy et al., 2007), and three were used in this study. These three frameworks are *foundationalism*, *coherentism*, and *reliabilism*. These three frameworks appear to be the most advocated and well-developed by current epistemologists (e.g., Bach, 2006; Fumerton, 2000; Kvanvig, 1986b; Shogenji, 2001). Items for this instrument were developed after a thorough search of the philosophical literature in epistemology (Bach, 2006; Beebe, 2004; Fumerton, 2000; Kvanvig, 1986a, 1986b, 2003; Moser, 1995; Shogenji, 2001, in press; Weiner, 2005). After reading the literature, the most important tenet for each of the epistemic frameworks was identified. Items were developed to reflect each of these tenets.

In addition, the purpose of this dissertation study was to investigate whether or not teachers evidence different epistemic belief profiles in their pedagogical practices. Thus, the items were written to reflect teaching practices that would be used to reflect each of the primary tenets of *foundationalism*, *coherentism*, and *reliabilism*. Three types of items (i.e., Likert-type, rank-scaling, and constructed-response), have been developed for use in this instrument.

Likert-Type Items

The first part of the newly created instrument consisted of 30 Likert-type items. The purpose of these items was to determine teachers' beliefs concerning the utility of pedagogical

practices reflecting specific epistemic frames. Responses on the ten items representing each epistemic frame (30 items total) ranged from 1 to 7. The Likert-type items consisted of different pedagogical practices designed around each of the central tenets of the epistemic frameworks. These items were written without specifying the content taught. This was done because these three epistemic frameworks have not previously been investigated in the literature, and it is unknown as to whether introducing content into the items will affect the responses of participants. An example of a *foundationalist* item was, "When I teach, I ask my students to explain how new information builds upon what is known to be true." This demonstrates a *foundationalist* perspective because the nature of beliefs that are basic and "known to be true" is emphasized in this item. An example of a *coherentist* item was, "As a teacher, I emphasize the links between as many concepts as possible." This item demonstrates a *coherentist* perspective because the content being addressed refers to the linkage between concepts. An example of a *reliabilist* item was, "I teach my students to justify their understandings with observable evidence." This item reflects a *reliabilist* framework because evidence that is external and observable is critical to this framework. In addition, all items were written to reflect the teacher's actions in the classroom relative to the epistemic frameworks. Careful attention was given to the wording of the items across the three epistemic frameworks. Specifically, the items were written so that the wording would be parallel across frameworks. This was done to ensure that the verbiage used in the items did not interfere with teachers' ratings. Each framework has one item about explanations, content, examples, and demonstrations. In addition, each framework has four items beginning with the statement, "I teach…," and two items beginning with the phrase, "As a teacher…." The full instrument is given in Appendix E.

Participants were asked to respond to each of the Likert-type items based upon the *usefulness* of the teaching practices for increasing students' knowledge. In other words, the Likert-type items were anchored with *Not Very Useful* and *Very Useful*. In order to do this, participants were asked to choose the number indicating the extent to which they believed the particular justification condition or teaching practice was useful to them.

Rank-Scaled Items

Participants were also asked to respond to twelve rank-scaled items. The purpose for these items was to determine teachers' beliefs regarding the importance of selected instructional activities, assessment, and cues or prompts reflecting specific epistemic frames. Four selected science contents were assessed (i.e., *Weather Patterns, Magnets, Plants,* and *Light*), with one item about instructional activities, assessment, and cues or prompts for each content area. These content areas were selected because they align with the fourth grade state standards for science (Pennsylvania Department of Education, 2002) in the state where the participants were completing their student teaching assignment. For these items, a prompt was given and three options reflecting one of the pedagogical practices mentioned above were given. For every item, three choices for pedagogical practices were written reflecting the three epistemic frameworks previously outlined. Participants were asked to rank the three options in order of least to most important in their teaching with no tied ranks. These rank-scaled items were given in addition to the Likert-type items because it is possible that teachers could answer the Likert-type items in such a way that they say they feel every type of justification condition and teaching practice will increase students' knowledge in positive ways due to over-confidence in their teaching abilities (e.g., Pajares, 1992). With the addition of the rank-scaled items, participants were asked to rate the relative importance of each of the teaching practices instead of responding that they feel all

of them are useful in good teaching. They were forced to choose which practices were most important to them in order. This was done because participants could have rated all the practices as being very important due to their confidence in their teaching (Pajares, 1992), thus making the rank-scaled items very similar to the Likert-type items. Instead, participants were required to rank all three pedagogical practices with no ties in order from *least* (1) to *most* (3) important to their own individual teaching.

Science content practices were assessed by these rank-scaled items. The science content was written on a fourth grade level, and the content used has been stated as being tested in Pennsylvania schools on the Pennsylvania System of School Assessment standards at the fourth grade level (Pennsylvania Department of Education, 2002). The fourth grade level was chosen because this is the grade at which science standards are written and assessed by the state.

Different areas of instructional practices (i.e., instructional activities, assessments, and cues or prompts) were assessed by these rank scaled questions for each of the four content areas listed above. An example of an instructional activities item was:

Plants

_____ Have students explore the relations between plant growth, survival, and reproduction. (*C*)
_____ Have students explain to another student the fundamental role photosynthesis plays in plant life. (*F*)
_____ Have students collect data and draw conclusions regarding the effect of varied amounts of light on plant growth. (*R*)

An example of an assessment item was:

Light

_____ Ask students to pretend they are a beam of light and describe their journey from a source to an object. (*F*)

_____ Ask students to explain how light travels from a light bulb to allow them to see the words on a piece of paper with their eyes. (*C*)

_____ Ask students to test their hypothesis about what can make a wall appear a different color than its original color. (*R*)

An example of an item assessing cues or prompts was:

Weather Patterns

_____ "Remember to think about how wind chill relates back to what you already know about temperature change." (*F*)

_____ "It may be helpful for you t draw a chart showing how wind speed, temperature, and cloud cover are related." (*C*)

_____ "What do you think would happen to temperature and precipitation if you changed the wind direction? Be sure to provide evidence." (*R*)

The full measure is located in Appendix E.

Constructed-Response Item

In addition to Likert-type and rank-scaled items, participants were asked to respond to one constructed-response item. The purpose of this item was to allow participants to give their opinion on pedagogical practices without any prompts of what they might want to do. This item was completed at the first testing administration time only, depending upon when participants first participated, and was the first item to which participants responded. For this item, participants were asked to tell about a science lesson they had taught in the past that they thought was effective. They were asked to give descriptive information about the lesson, such as the approximate date it was taught and the unit for which it was planned. In addition, participants were asked to describe the instructional activities and assessments used, as well as any cues or prompts they gave to the students to help them understand. Specifically, the descriptions were

broken down into sentences and coded separately. Each of the sentences was coded according to whether the participant gave evidence of a *foundationalist*, *coherentist*, or *reliabilist* belief, or whether they did not give evidence of any of the three epistemic frameworks.

Validity of the Scientific Content

A number of different techniques were used to determine whether scores on the newly created instrument have content validity. First, the validity of the science content and pedagogical practices was assessed to determine whether the items reflect content and practices appropriate for elementary school. In order to assess this, the instrument was given to three experts in science education and pedagogical practices. One of the experts was a high school teacher, one was Associate Professor of Science Education, and the third was the Director of the Center for Science in the Schools at Penn State University. These three experts were asked to determine whether the practices and the science content is appropriate for elementary school, and to provide input as to how the assessment can be made more appropriate. The instrument was modified based upon the input of these experts.

Modifications were made on the content of some of the science content used in the rank-scaled items. For example, in the item assessing instructional activities about *Weather Patterns*, the *foundationalist* item was changed from "Have students understand the fundamental concept of barometric pressure" to "Have students describe the fundamental concept of convection." The content of this item was changed in two ways based upon the recommendations of the experts. First, the science experts told me that the concept of barometric pressure is not a fundamental concept that is taught in elementary school, and suggested that the fundamental concept of convection would align better with the fourth grade science standards. In addition, the experts suggested that the word "understand" is not an instructional activity. Thus, the description of the

instructional activity was changed to "describe." The same verbiage problem occurred in a number of other *foundationalist* items and was corrected in all of them to reflect instructional activities. The wording of the items was only changed when the integrity of the epistemic frameworks could be maintained. The entire modified instrument is included in Appendix E.

Validity of the Content of the Epistemic Frameworks

In addition, the instrument was assessed to determine the appropriateness of the items as they reflect the epistemic frameworks of *foundationalism*, *coherentism*, and *reliabilism*. Graduate students enrolled in a doctoral seminar about knowledge and beliefs were asked to assess the items for how they reflect the frameworks. As part of their course content, these graduate students were required to read, study, and discuss the Murphy et al. (2007) book chapter, which gives an overview of these three epistemic belief frameworks. After class discussion, these graduate students were given both the Likert-type and rank-scaled items. They were asked to determine which epistemic framework they believed was assessed by each of the Likert-type items, as well as for each of the three options for the rank-scaled items.

A total of eight graduate students participated in this data collection. Of these eight graduate students, data from only five were compiled to determine whether or not the items on the newly created instrument reflected the epistemic frameworks. These graduate students correctly rated the majority, if not all, of the items as belonging to the epistemic framework for which they were designed. These five graduate students were classified as having high knowledge of the epistemic belief frameworks. The other three graduate students incorrectly rated over half of the items as belonging to the epistemic framework for which they were designed. They were subsequently classified as having low knowledge about the epistemic frameworks. Because of the disparity in the two groups, it was determined that the three graduate

students incorrectly rating the majority of items did not have a clear understanding of the epistemic frameworks and were unable to determine from which epistemic framework each item came.

Data from the five graduate students classified as having high knowledge about the epistemic belief frameworks were compiled and modifications were made based upon the results to ensure the items clearly reflected each of the epistemic frames. Eight of the items were incorrectly identified by two of the five graduate students who were classified as high knowledge, and were modified to more clearly reflect the epistemic frameworks. For example, items assessing a *reliabilist* belief framework were modified based upon these incorrect identifications. This belief framework suggests that knowledge is justified by the use of a reliable cognitive process. Cognitive processes are deemed to be reliable when the results of their use match data collected from the natural environment. One such item assessing a *reliabilist* framework originally read, "I use demonstrations in my teaching to show how reasoning can be confirmed with evidence." This item was modified to read, "I use demonstrations in my teaching to show how reasoning can be confirmed with data collected as evidence." This modification was made because the item did not clearly state that observable data is vital in a *reliabilist* framework. Thus, the raters did not originally rate the item as evidencing a *reliabilist* framework. A second item, "As a teacher, I show that explanations based on observable evidence are more sound than other explanations," was also modified to read, "As a teacher, I show that explanations based on observable evidence are more viable than explanations not based on observable evidence." The raters were not clear about what types of explanations were used, and, thus, they failed to rate the item as a *reliabilist* item. Other modifications were made, and the modified instrument is included in Appendix E.

External Measures of Personal Epistemology

The relations between scores obtained from the newly created instrument could be similar to scores obtained from other instruments assessing the use of evidence already found in the personal epistemology literature. Items from these instruments that have been identified as measuring evidence and justification were compiled and given to participants. Specifically, three instruments were identified as having factors assessing evidence or justification of knowledge (i.e., Conley et al., 2004; Elby, n.d.; & Hofer, 2000). Because this dissertation study investigates the use of differing justification conditions as they relate to teachers' pedagogical practices, items assessing the justification factors from these three instruments were given to participants. These items were anchored with *strongly disagree* and *strongly agree* in the same way as they were previously used in the literature, and were also assessed on a 7-point Likert-type scale. Of the three factors, only one appeared to be assessing the use of justification similarly to the ways in which justification is conceptualized for this dissertation study. Specifically, the justification factor on Conley et al.'s (2004) assessment appeared to be evidencing a *reliabilist* epistemic framework. The items inherent in Conley et al.'s (2004) justification factor assess beliefs about the use of observable data collected from experiments to draw conclusions. Thus, scores obtained from this factor may be related to scores on the *reliabilist* items.

Video Narratives of Teaching Practices

The final piece of data collected for this dissertation study consisted of the narratives of teaching videos compiled by the preservice teacher participants. As a part of the requirements for their science teaching methods course, intern participants made a video of their teaching in the Fall 2006 semester. Specifically, the interns planned and taught a three-day lesson sequence in science. They videotaped these lessons and compiled ten-minute videos exhibiting the best

evidence from the lessons that their students learned the instructed content. The videos were then narrated by the intern, including descriptions of the science activity on the video and an evaluation of how the intern knew the students had acquired the content.

For this dissertation study, the narratives of the videos were analyzed. Specifically, the narratives were transcribed and broken into sentences. The sentences were then coded as belonging to one of the three epistemic frameworks (i.e., *foundationalism*, *coherentism*, and *reliabilism*) or whether they did not evidence any of the frameworks. This was done in the same way as for the constructed responses.

Procedure

Participants were asked to participate in this study both at regularly scheduled meetings and via emails. Preservice teacher participants who were eager to participate in the study (i.e., they participated at both times one and two without being reminded), were also asked to grant the researcher permission to use the videos they created for their science methods course in Fall 2006 for this dissertation research. Of these participants, five granted permission to use their videos for this study.

Data from the survey were collected from preservice participants using the previously described assessment by utilizing the Survey Monkey website (www.SurveyMonkey.com) at two time points; at the beginning of both March and April. At the beginning of May, participants were asked to respond to the same survey on paper during a regularly scheduled seminar. At each time point, participants were asked to complete both the Likert-type and rank-scaled items. Preservice participants were also asked to respond to the constructed-response item at the first time they took the assessment. Participants were asked to log onto Survey Monkey to complete the newly created assessment at times one and two. In addition, they were asked to complete a

short survey consisting of personal epistemology items from previously published items (i.e., Conley et al., 2004; Elby, n.d.; Hofer, 2000). Participation at each time point took approximately 20 minutes.

Participation for inservice teachers was similar, but only occurred at two time points. Data were collected from inservice teachers on Survey Monkey at the first time point and on paper at the second time point. The first time point occurred immediately after nine-week grades were due, at the beginning of April. The second data collection point occurred at the beginning of May. However, as previously described, all mentor data were compiled into one set of data.

Data Analysis Procedures

In order to answer the research questions listed above, a number of data analysis procedures were employed. To answer the first group of questions on the reliability of scores, the accuracy of the epistemic belief profiles must first be established. The accuracy of the epistemic belief profiles was addressed first because accuracy of results is a vital component inherent in reliability. Without establishing accurate profiles of teachers' beliefs, many of the other research questions cannot be answered.

To determine the epistemic belief profiles for teachers using Likert-type items, composite scores for each of the three epistemic frameworks were calculated by adding the ratings for each of the items assessing a particular epistemic framework. Profiles were then created by investigating the margin of error at each data collection point. Specifically, the margin of error for all composite scores at each data collection point was found. This value was used as a cut-off point to determine whether teachers evidenced significantly different scores on each of the three frameworks. If the composite scores on two epistemic belief frameworks for an individual differed by at least as much as the margin of error, it was concluded that the teacher rated those

two frameworks significantly differently from each other. Epistemic belief profiles were also established for responses to the rank-scaled items. Specifically, composite rankings for each of the epistemic frameworks were summed across each content area. Profiles were determined based upon the pattern of the composite score profile. Epistemic belief profiles were also established based upon data collected from the lesson descriptions and video narratives. Two coders independently coded each sentence in ten percent of the lesson descriptions or narrations as belonging to one of the previously identified epistemic belief frameworks. After a high level of inter-rater agreement was established, the total numbers of sentences evidencing each of the epistemic belief frameworks were then added. To create the profiles of epistemic beliefs for each individual, the margin of error was again investigated as previously described.

The next research question addressed the degree to which the scores obtained on this instrument are internally consistent. This is a pressing research question because it is important to determine whether the items on an assessment consistently assess constructs in the same way. As such, the internal consistency of the Likert-type items was established by investigating Cronbach's alphas for the entire sample and then separately for preservice and inservice teachers.

The final reliability question addressed the issue of the stability of scores resulting from the use of this newly created instrument. In order to be viable for use, a methodological system must address the degree to which individuals' scores remain consistent over time. Thus, the stability of scores obtained from preservice teachers over three different time points was assessed. First, the stability of the composite scores as measured by the Likert-type items was assessed. For this dissertation study, test-retest reliability of the composite scores for each epistemic framework was assessed using Pearson's correlation coefficients. Second, the stability of the belief profiles was investigated. Chi-square tests of independence were also calculated

between preservice teachers' epistemic belief profiles at Times 1 and 2 and again at Times 2 and 3 to determine the degree to which the epistemic belief profiles were consistent across times.

The stability of scores from the rank-scaled items was also assessed in two ways. First, an investigation of the extent to which the composite rankings were stable was completed. Composite rankings for *foundationalist*, *coherentist,* and *reliabilist* items were submitted to correlational analysis using Spearman's rho procedures. Specifically, correlations between rankings of items assessing each epistemic belief framework were investigated across the three time points. Second, the consistency of the belief profiles for each content area across times was investigated. Chi-square tests of independence were utilized to determine whether the belief profiles for each content area were consistent over time.

A number of questions addressed the convergent validity of scores obtained from this new instrument were also assessed in this dissertation study. The first research question addresses the extent to which the scores obtained on the Likert-type items are related to each other. This is important to investigate because no studies have been conducted on the relations among the three epistemic frameworks investigated here. In order to do this, correlation coefficients between composite scores for Likert-type items evidencing each of the three epistemic belief frameworks were investigated. These correlations were investigated independently at each time point.

The second research question investigated the relations among the profiles obtained from the different types of data for this dissertation. Profiles for four types of data (i.e., Likert-type items, rank-scaled items, descriptions of effective lessons, and video narrations) were obtained in this study. Chi-square tests of independence were used to investigate the relations between the Likert-type profiles and the profiles obtained from the lesson descriptions. Due to the small

number of video narrations collected, a descriptive analysis of the data collected was completed to compare the relations between the epistemic belief profiles obtained from these narrations and the Likert-type items. The relations between the profiles obtained for the rank-scaled items and other types of profiles was not investigated due to the lack of stability of the profiles over the four topic areas assessed by the rank-scaled items.

The final research question investigated the validity of the instrument relative to external criteria. Specifically, the scores derived from subscales on three previous studies on epistemic beliefs in which scores had been established as valid (i.e., Conley et al., 2004; Elby, n.d; & Hofer, 2002) were correlated with the three subscales on the Likert-type assessment. Items from these three instruments in the personal epistemology literature were used because the authors claim to assess individuals' methods of justification in these items. In order to determine the relations between the composite scores on the Likert-type items and scores on these external measures, correlation coefficients were analyzed.

CHAPTER 4

RESULTS AND DISCUSSION

Chapter four has two primary sets of research questions. These research questions address the reliability and validity of the scores obtained from the new instrument. Given the two primary purposes of this dissertation (i.e., to introduce a new methodological system for understanding beliefs, and to assess the beliefs of preservice and inservice teachers with this new instrument), the research questions that are addressed follow classical views of reliability and validity. Reliability information is provided for the complete sample, and then independently for the preservice and inservice teachers. Validity information is provided separately for preservice and inservice teachers, and then is compared descriptively due to the anticipated differences between the responses of these two groups of teachers.

Reliability of Scores

The reliability of the new instrument was assessed first. Reliability questions are as follows:

1. *Reliability*
    a. To what extent are teacher epistemic frame profiles consistent across item type and within selected pedagogical practices?
        i. To what degree can belief profiles be identified for Likert-type items?
        ii. To what degree can belief profiles be identified for each epistemic framework across science content areas in the rank-scaled items?
        iii. To what degree can the descriptions of lessons given on the constructed-response items be rated similarly by independent raters?

b. To what extent does the instrument produce internally consistent scores to assess *teacher epistemic beliefs* as measured by the Likert-type items?
c. To what extent does the instrument provide stable scores of *teacher epistemic beliefs* as measured by the Likert-type and rank-scaled items?

The first set of reliability questions relate to the accuracy and precision of classifying or profiling individuals according to one or more epistemic frameworks. Because this issue deals with accuracy of classification, it is handled as a question of reliability in this dissertation. Two sets of analyses are conducted to answer this research question. The first assesses the responses to the Likert-type questions and addresses whether individuals hold a predominant epistemic frame versus one that is more mixed in terms of its profile. The second reliability question is related significantly to the first. However, responses to the rank-scaled questions addressing teachers' likely pedagogical practices are analyzed for this question.

Reliability is then assessed by investigating the internal consistency of the scores on the newly created measure of teacher epistemic beliefs. Internal consistency is important to investigate because total score variability affects estimates of reliability (McDonald, 1999). However, it is not known whether belief scores on the Likert-type items are heterogeneous or homogenous. Therefore, it is important to interpret the internal consistency estimates not only for reliability as viewed from traditional measurement practices, but also to determine whether teachers are differentiated based on the responses they provide to these items. Higher reliability, however, shows that scores are more internally consistent and that the epistemic frameworks of *foundationalism*, *coherentism*, and *reliabilism* were well-chosen to differentiate beliefs.

The next reliability question addresses the issue of the stability of scores produced from this newly created instrument. For a methodological system to contribute to the literature on the

study of beliefs, it must address the degree to which individuals' beliefs remain consistent over time. The literature documents clearly that individuals at various levels of academic development (Murphy & Alexander, in press) are prone to have different levels of consistency in their beliefs. Thus, the stability of scores obtained from preservice teachers over three different time points was assessed.

The final question of reliability examines actual pedagogical practices of teachers. An important contribution of this dissertation is to examine the alignment of self-reported beliefs with actual pedagogical practices. As such, the results of this dissertation offer ecologically valid scores. However, in order for these results to be deemed ecologically valid, the practices must first be rated consistently by more than one observer. Thus, this last reliability question focuses on the pedagogical practices specifically and inter-rater agreement techniques are employed to determine the reliability of scores.

Identification of Belief Profiles from Likert-Type Items

In order to determine participants' score profiles on the Likert-type items, composites of items representing *foundationalism*, *coherentism*, and *reliabilism* were created by adding the ratings of the ten items assessing each of the epistemic belief factors. Descriptive statistics for these three factors at each data collection point are given in Table 9.

Table 9

Descriptive Statistics for All Administrations of the Survey.

	Time 1 Interns (N=33)		Time 2 Interns (N=20)		Time 3 Interns (N=50)		Mentors (N=16)	
	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s
All participants								
foundationalism	53.97	5.405	53.75	6.512	54.38	7.423	55.17	6.162
coherentism	59.70	5.997	61.20	7.023	59.38	7.491	63.00	3.977
reliabilism	61.00	5.202	60.40	5.196	60.04	6.433	61.83	5.997
Interns who participated at all times (N=17)								
foundationalism	54.89	5.830	51.59	6.052	54.35	4.636		
coherentism	60.59	6.764	59.59	7.255	59.71	5.289		
reliabilism	61.24	5.718	59.76	6.897	61.00	3.447		

In order to develop profiles from the composite scores for each of the three epistemic belief frameworks, the margin of error was calculated for all composite scores, regardless of the factor they represented. The margin of error over all composite scores was investigated because composite scores for the three factors may be different, and one margin of error over all the data should be used to determine the guideline for how far apart scores need to be. This guideline was then used to assess whether the composite scores for individuals were significantly different or not. For example, 16 mentor teachers completed the Likert-type items. Each mentor teacher responded to items comprising all three frameworks. Thus, each mentor teacher would have three composite scores, for a total of 48 composites. The standard error was first found for these 48 scores, as well as for the total number of composite scores for the interns at Times 1, 2, and 3. Each of the standard errors were then multiplied by 1.96, or the z-score for the 95% confidence interval, to determine the margin of error value by which composite scores need to be different. If scores differed by more than the margin of error, they were deemed to be significantly different. Data for all time administrations of the survey are given below.

For Time 1, the standard error for all composite scores (n=99) was .632. When this standard error was multiplied by 1.96, the margin of error was 1.24. Thus, composite scores for participants at Time 1 must have differed by at least 1.24 in order to give evidence of different epistemic belief profiles. For Time 2, the standard error for all composite scores (n=60) was .960. The margin of error at Time 2 was 1.88. Composite scores for participants at Time 2 must have differed by at least 1.88 in order to give evidence of different epistemic belief profiles. For Time 3, the standard error for all composite scores (n=150) was .614. The margin of error at Time 3 was 1.20. For this time point, composite scores for participants must have differed by at least 1.20 in order to give evidence of different epistemic belief profiles. For the inservice

teachers, the standard error for all composite scores (n=48) was .905. The margin of error for the inservice teachers was 1.77. In other words, inservice teachers must evidence composite scores that differ by at least 1.77 in order to be classified as having different epistemic belief profiles.

The margins of error were different due to both the standard deviations and to the sample size at the different data collection points. However, the sample size was the determining factor in the differences in the margins of error. Specifically, at data collection points when the sample size was larger, the margin of error was smaller and when the sample size was smaller, the margin of error was larger. In order for composite scores at any one time point to be considered significantly different, the difference between them must have been greater than the margin of error at that time point. Because all margins of error were between one and two, the composite scores must have differed by at least two to be considered significantly different.

Thus, in order for one epistemic belief framework to be rated higher than the other belief frameworks, the composite score must be higher by a score of at least two for any given administration of the assessment. For example, if composite scores for one participant are 58, 61, and 65 for *foundationalism*, *coherentism*, and *reliabilism* respectively, the participant would be classified as having a *reliabilist* profile because the *reliabilist* composite is higher than the other two beliefs by an amount greater than the margin of error, or at least two points. If composite scores for a participant are 56, 61, and 62 respectively, the participant would be classified as having a *mixed* (*coherentist*, *reliabilist*, in this case), profile because the composite scores for *coherentism* and *reliabilism* do not differ by more than the margin of error, but they both differ from the composite score for *foundationalism* by more than the margin of error. For Time 1, 13 preservice teachers evidenced a *reliabilist* profile, ten evidenced a *coherentist* profile, and ten evidenced a *mixed* epistemic belief profile. For Time 2, five preservice teachers evidenced a

reliabilist profile, six evidenced a *coherentist* profile, and eleven evidenced a *mixed* profile. For Time 3, 17 preservice teachers evidenced a *reliabilist* profile, 14 evidenced a *coherentist* profile, and 19 evidenced a *mixed* profile. For the inservice teachers, six evidenced a *reliabilist* belief, seven evidenced a *coherentist* belief, and four evidenced a *mixed* belief.

Identification of Belief Profiles from Rank-Scaled Items

Composite scores for each of the epistemic frameworks were created for each topic area across pedagogical practices in order to develop a number of profiles of teachers' reported beliefs. For each topic area, three types of pedagogical practices were measured in the newly created epistemic beliefs instrument. Composite scores were created by adding the rankings representing each of the epistemic frame profiles across pedagogical practices within each topic area. Data for the rank-scaled items for participants who had consistent epistemic belief profiles across each of the topic areas when the order of epistemic frameworks was *foundationalism*, *coherentism*, and *reliabilism*, will look like:

Activities: 2, 1, 0;

Assessment: 2, 1, 0;

Cues or Prompts: 2, 1, 0.

This data was expected to occur when one of the epistemic frameworks was consistently endorsed as being most important in the classroom and another epistemic framework was consistently reported as being least important for the teacher's classroom. If *foundationalism* in this example was always endorsed highly and *reliabilism* was always rated as least important, composite scores for the epistemic frameworks would look like:

foundationalism: 6; *coherentism*: 3; *reliabilism*: 0.

This epistemic belief profile was called *consistent* for the topic area. A complete list of epistemic belief categories are provided in Tables 10 and 11.

Data for participants who consistently endorsed two epistemic belief frameworks over the third epistemic framework had the following pattern:

Activities: 2, 1, 0;

Assessment: 1, 2, 0;

Cues or Prompts: 1, 2, 0.

In this example, if *foundationalism* and *coherentism* were the two profiles endorsed over *reliabilism*, composite scores for the epistemic frameworks had the following pattern:

foundationalism: 4; *coherentism*: 5; *reliabilism*: 0.

This epistemic belief profile was called *consistent across two frames* for the first topic area.

Table 10

Composite Score Profiles for Participants Who Rate Foundationalism or Coherentism Highest

(F, C, R) **(C, F, R)**	**Rank**	**Description**	**Overall** **Category**	**Consistency** **Category**	**Compatibility** **Category**
6, 3, 0	1	Consistent; Epistemically	1	1	1
5, 4, 0	2	compatible	1	1	1
6, 2, 1	3	Moderately consistent;	2	2	1
5, 3, 1	4	Epistemically compatible	2	2	1
4, 4, 1	5		2	2	1
5, 2, 2,	6		2	2	1
6, 0, 3	7	Consistent; Epistemically	3	1	2
5, 0, 4	8	incompatible	3	1	2
6, 1, 2	9	Moderately consistent;	4	2	2
5, 1, 3	10	Epistemically incompatible	4	2	2
4, 1, 4	11		4	2	2
4, 3, 2	12	Inconsistent	5	3	3
4, 2, 3	13		5	3	3
3, 3, 3	14		5	3	3

Table 11

Profiles for Participants Who Rate Reliabilism Highly

(R, F, C) **(R, C, F)**	**Rank**	**Description**	**Overall (Consistency)** **category**
6, 3, 0	1	Consistent	1
6, 0, 3			
5, 4, 0	2		1
5, 0, 4			
6, 2, 1	3	Moderately Consistent	2
6, 1, 2			
5, 3, 1	4		2
5, 1, 3			
4, 4, 1	5		2
4, 1, 4			
5, 2, 2	6		2
4, 3, 2	7	Inconsistent	3
4, 2, 3			
3, 3, 3	8		3

It was also possible that participants would mix their endorsements across all three epistemic belief categories within one topic area. An example of this data would have the following pattern:

Activities: 2, 1, 0;

Assessment: 1, 0, 2;

Cues or Prompts: 0, 2, 1.

In this example, none of the epistemic frameworks were endorsed over any of the others, and composite scores for the frameworks would be as follows:

foundationalism: 3; *coherentism*: 3; *reliabilism*: 3.

This epistemic belief profile would be called *mixed* for the first topic area.

These were not the only options for epistemic belief profiles. However, the three categories of belief profiles, *consistent*, *consistent across two frames*, and *mixed* were used for other possible belief profiles. Composite scores were calculated for each topic area in the same way to determine the category of epistemic belief profile for each teacher across the four tested topic areas. Thus, each teacher was categorized as having profiles of beliefs four times, one for each topic area. Table 12 gives the number of participants who evidenced each of the epistemic belief profiles.

Table 12.

Number of Participants Evidencing Different Epistemic Belief Profiles at Each Data Collection Point for Rank-Scaled Items

	Time 1 interns			Time 2 interns			Time 3 interns			Mentors		
	R	C	mix	R	C	mix	R	C	mix	R	C	mix
WP	5	0	28	3	4	14	10	8	30	3	1	11
M	18	0	15	6	0	15	21	0	27	6	1	8
P	5	1	27	4	2	15	6	9	33	2	2	11
L	15	1	17	10	0	11	20	0	28	9	0	6

R = *reliabilist belief profile*; C = *coherentist belief profile*; mix = *mixed belief profile*; WP = *Weather Patterns*; M = *Magnets*; P = *Plants*; L = *Light*

When the epistemic belief profiles of teachers were investigated by grade level, no patterns were found in the data. In other words, participants did not show evidence of differing belief profiles if they taught different grade levels. This may be due to the fact that there were few teachers participating for each grade level. Differences may be detected if more data was collected.

Inter-Rater Agreement on Coding Lesson Descriptions

In addition to completing the newly-created instrument, preservice and inservice teachers were asked to describe an effective science lesson they have taught in the past year as a measure of their demonstrated practices. This lesson description was collected from the participants at the first time in which they participated in the study. In order to determine whether evidence of the

realization of epistemic beliefs in teaching could be coded consistently by multiple raters, ten percent of these constructed-response items were double-coded by both the researcher and a trained rater. Each constructed-response was broken into sentences before coding so the sentences could be coded individually for evidence of one of the three epistemic beliefs being studied in this dissertation.

The rater was trained in the following way. First, discussions between the rater and the researcher about each of the epistemic frameworks were completed during the six months before data collection so the rater had an understanding of the three epistemic belief frameworks used in this study. The rater was then given working definitions of each of the three epistemic belief frameworks to use when rating each of the sentences in the lesson descriptions. Examples of each of the frameworks were given to the rater, as well as examples of statements that did not evidence any belief framework. The rater was then asked to rate each of the sentences in the lesson descriptions according to whether they evidenced *foundationalist*, *coherentist*, or *reliabilist* beliefs, or whether the sentence did not evidence any of these beliefs.

Ten percent of the lesson descriptions were coded by the researcher and the trained rater. This amounted to lesson descriptions provided by six teachers. All 33 sentences in these six lesson descriptions were double-coded. Of these 33 sentences, 29, or 88%, of the sentences were coded the same by both the rater and the researcher. Because of the high inter-rater agreement on these codings, no additional training or coding by the second rater was completed. All remaining sentences were coded independently by the researcher. Score profiles were then created for each of the preservice and inservice teachers on the constructed-response items by adding the number of sentences evidencing a *foundationalist*, *coherentist*, or *reliabilist* belief. The narrations of the

videos collected from the preservice teachers were also coded independently by the researcher, as the same method for coding was used.

Profiles for the lesson descriptions were only developed if the participant had at least two codable statements. If a participant has only one codable statement, this may not be indicative of their epistemic beliefs. In addition, the margin of error was calculated for the number of lesson statements and was used in the same way as previously described for the Likert-type profiles. Specifically, the margin of error for all participants was .405, meaning that the number of statements evidencing each of the epistemic belief frameworks needed to be greater than .405 apart in order to be significantly different. For the preservice teachers, 20 evidenced a *reliabilist* belief profile, nine evidenced a *coherentist* profile, and ten evidenced a *mixed* profile. Profiles were not established for six participants who provided lesson descriptions because of the lack of codable statements. For the inservice teachers, four evidenced a *reliabilist* belief profile, three evidenced a *coherentist* belief profile, and six evidenced a *mixed* epistemic belief profile. Profiles were not established for two inservice participants who provided lesson descriptions because of the lack of codable statements.

Internal Consistency of Scores

In order to answer the next research question, the internal consistency of the scores on items assessing each of the epistemic frameworks must be found for the Likert-type items. To do this, Cronbach's alphas were calculated first for scores obtained for all participants. Specifically, data for preservice teachers at the first time they responded to the instrument and for inservice teachers were used to calculate an overall Cronbach's alpha for the entire set of 30 Likert-type items. Cronbach's alphas for each of the sets of ten items assessing *foundationalist*, *coherentist*, and *reliabilist* beliefs for all participants were then calculated from the full sample.

Internal consistency reliabilities of scores were then calculated for preservice and inservice teachers separately. In addition, internal consistency was assessed for preservice teachers separately for each of the three time points. Alphas were calculated for preservice teachers at each of the three time points and for inservice teachers similarly to how they were calculated for all participants. Cronbach's alphas were calculated for each of the epistemic frameworks separately because it was assumed that participants will respond to items assessing different epistemic frameworks in diverse ways.

Internal consistency reliability of scores was first assessed for the Likert-type items for all participants. Many of the interns participated in this study at multiple time points. In order to assess the internal consistency for all participants, data from the first time when the interns participated were used. Cronbach's alpha was calculated using the data from 68 of the 72 participants in this study because they provided data for each question. The Cronbach's alpha for the entire set of 30 Likert-type items was calculated to be .881. Cronbach's alphas were also calculated separately for items assessing each of the three epistemic belief frameworks. For *foundationalist* items, alpha was found to be .703. For *coherentist* items, alpha was found to be .807. For *reliabilist* items, alpha was calculated to be .830. These are acceptable levels for internal consistency reliability. The complete set of reliability analyses are given in Table 13.

Results of the Cronbach's alpha analyses for the preservice teachers showed that each of the three factors inherent in the Likert-type items were fairly reliable at all three time points. Cronbach's alphas for the *foundationalist* items ranged from .665 to .808 over the three administrations of the survey. Alphas also ranged from .823 to .887 for *coherentist* items, and from .774 to .873 for *reliabilist* items over the three time points. These alphas are all in the acceptable range for a newly created measure.

Reliabilities for the entire set of scores from the Likert-type items were calculated for all three time points for preservice teachers, and ranged from .882 to .935 for all 30 items. It was not expected the reliabilities to be quite this high for the overall instrument because the instrument was designed to have three distinct factors that respondents might rate differently. However, the large number of items may have increased the reliability of the overall survey.

Table 13

Cronbach's Alpha Reliability for Likert-Type Items

	Overall sample		Time 1 Interns		Time 2 Interns		Time 3 Interns		Mentors	
	N	α	N	α	N	α	N	α	N	α
New instrument	68	.881	33	.882	22	.935	42	.903	16	.829
foundationalist (10 items)	68	.703	33	.665	22	.808	47	.805	16	.676
coherentist (10 items)	68	.807	33	.823	22	.887	45	.855	16	.698
reliabilist (10 items)	68	.830	33	.774	22	.873	48	.869	17	.731
Existing instruments										
Conley et al. (2004)			33	.701	20	.680	47	.672	16	.658
Elby (n.d.)			33	.382	20	.079	48	.667	16	.444
Hofer (2000)			33	.286	20	.216	47	.653	16	.758

For inservice teachers, Cronbach's alphas for scores representing the three factors are very similar to those for the preservice teachers. The reliability for the overall instrument was found to be .829. Alpha was .676 for the *foundationalist* factor, .698 for the *coherentist* factor, and .731 for the *reliabilist* factor. These reliabilities were based upon fewer participants than the reliabilities obtained for the scores from the preservice teachers. Thus, it would seem that the scores from the inservice participants are more reliable than the scores obtained from the preservice teachers. This is reasonable, as the inservice teachers have more experience teaching than the preservice teachers. Thus, they may have better conceptualizations about what practices work for them in their classrooms.

One thing that is noticeable about these Cronbach's alphas for the interns is that the lowest reliability is evident at Time 1. Reliabilities increased for the second and third administrations of the survey. This may be due to the fact that the first administration of the assessment was given in March. The preservice teachers had only been teaching for a short time in March, and may not have had as clear of ideas as to what they deemed to be acceptable evidence than they did in April and May for the second and third administrations of the survey. Thus, the lower Cronbach's alphas for the three factors at Time 1 are expected.

These lower reliabilities at Time 1 for preservice teachers may be due to the fact that they have limited pedagogical knowledge and experiences. Although they have been taught many practices to use in their classrooms, they are still beginning their experiences with teaching. Their beliefs may not yet be connected to their knowledge (Murphy, 2007) of teaching because of this lack of experience. In other words, their knowledge of pedagogical practices is not yet contextualized (e.g., Barab & Squire, 2004; Collins, 1992; di Sessa & Cobb, 2004) so they may be inconsistent in their ratings of beliefs.

Preservice teachers' beliefs become more internally consistent as they progress through their student teaching experiences, as evidenced by the fact that reliabilities increase at Time 2 with fewer participants. Although the reliabilities of the composite scores collected from mentor teachers are in the same range as the reliabilities of the composite scores of the interns at Time 1, this may be due to the small sample size. Because of the amount of experience the mentor teachers have in the classroom, these reliabilities may increase given more data. Still, the reliabilities calculated in all analyses were in the acceptable range.

Stability of Scores from Likert-Type Items

Unfortunately, not enough data were able to be collected from the inservice teachers to test the stability of estimates of their epistemic beliefs over time. However, the measure was given to preservice interns at three time points. Composite scores for each of the epistemic frameworks for the Likert-type items were calculated. Test-retest reliability for the Likert-type items was used to determine whether or not the epistemic beliefs as reported on these items remained consistent across the three administrations of the assessment.

Table 14 provides correlations between composite scores from Likert-type items assessing *foundationalist*, *coherentist*, and *reliabilist* items for Times 1, 2, and 3. Correlations between the factors range from .256 to .686 between Times 1, 2, and 3, with all but two correlations being significant at the .05 level. Thus, because of the significant relations between composite scores, there is evidence to suggest that the three factors provide stable estimates of preservice teachers' epistemic beliefs over time.

Table 14

Correlations Among Time 1, 2, and 3 Administrations of Likert-Type Items on New Instrument for Preservice Interns.

	Time 2			Time 3		
	F	C	R	F	C	R
Time 1						
Foundationalist	.490 (18)*			.370 (29)*		
Coherentist		.686 (18)**			.542 (29)**	
Reliabilist			.507 (18)*			.256 (29)
Time 2						
Foundationalist				.331 (20)		
Coherentist					.562 (20)**	
Reliabilist						.536 (20)*

Note: Numbers in parenthesis indicate sample size. F = *Foundationalist*, C = *Coherentist*, R = *Reliabilist*.

* Correlation is significant at .05 level.

** Correlation is significant at .01 level.

In order to further assess the stability of epistemic belief profiles over time, the consistency of the interns' profiles was also analyzed using chi-square tests of independence. Specifically, as described previously, interns were categorized as having *reliabilist*, *coherentist*, or *mixed* epistemic belief profiles at Times 1, 2, and 3 based upon their responses to the Likert-type items. These epistemic belief profiles were compared to each other (i.e., Time 1 versus

Time 2, and Time 2 versus Time 3) to determine whether or not their belief profiles were consistent over time.

Eighteen interns participated at both Times 1 and 2. Chi-square analyses revealed that there was not a significant relation between their epistemic belief profiles at these two time points ($\chi^2 = 7.371$, df = 4, p = .118). This result may be due to the small sample size. Ten of the 18 participants evidenced beliefs in the same epistemic belief category across the two times. Specifically, three evidenced a *reliabilist* profile, three evidenced a *coherentist* profile, and four evidenced a *mixed* profile at these two times. In addition, three participants moved from a *mixed* epistemic belief category at Time 1 to either a *reliabilist* or a *coherentist* belief profile at Time 2. However, five participants moved into the *mixed* category from one of the other two categories, which gives evidence that preservice teachers' beliefs may be relatively unstable.

Similar results were found when comparing epistemic belief profiles for interns at Times 2 and 3. Although the relations between the belief profiles were not significant ($\chi^2 = 8.933$, $df = 4$, $p = .063$), they approached significance. In addition, 11 of the 20 interns who participated at these two time points remained in the same epistemic belief category. Specifically, four evidenced a *reliabilist* profile, two evidenced a *coherentist* profile, and five evidenced a *mixed* belief profile at both time points. Further, six participants moved from the *mixed* category to a profile rating only 1 epistemic framework highly.

Significant relations were found between the composite scores obtained on each of the epistemic frameworks. Thus, there is evidence of the stability of these composite scores over time. From a measurement perspective, these significant correlations are a good indicator that the instrument assesses beliefs in the same way over time. However, more research must be conducted to determine the stability of the scores. Research is needed because the survey was

given to participants at three time points that were somewhat close together. Thus, the results may be due in part to carry-over effects.

Although many of the correlations were significant, they were in the moderate range. This again may be due to the fact that preservice teachers are becoming more stable in their own epistemic beliefs. From Time 1 to Time 2, three participants moved from a *mixed* epistemic belief framework to one that evidences only one primary belief framework. One evidenced a *reliabilist* framework and two evidenced a *coherentist* framework. In addition, six participants moved from a *mixed* belief profile to one endorsing a primary framework between Times 2 and 3. Only one evidenced a *reliabilist* framework at Time 3. The other five evidenced a *coherentist* epistemic belief framework. Thus, there is some evidence that as preservice teachers gain more experience in the classroom and gain in pedagogical knowledge, their beliefs become more consistent. Again, this may be due to the fact that their knowledge of pedagogy is becoming more contextualized (Collins, 1992; di Sessa & Cobb, 2004).

In addition, participants appeared to move into beliefs that were more *coherentist* in nature. This may be due to the curriculum in the district in which they taught. Specifically, the curriculum is organized around thematic units (State College Area School District, 2006), with connections between content areas being emphasized. This curriculum structure may have been the catalyst that promoted the development of more *coherentist* beliefs among preservice teachers.

Stability of Scores from Rank-Scaled Items

The stability of epistemic belief profiles obtained from rank-scaled items was also assessed. In order to determine whether the teachers consistently espoused the same epistemic belief frameworks across the four topic areas, Spearman's rho correlations were used. The

correlation coefficients between each of the three epistemic frameworks (i.e., *foundationalism*, *coherentism*, and *reliabilism*), were calculated across the topic areas using the composite scores for each of the topic areas at each time point separately. For example, if the composite scores for *foundationalism* were highly correlated across the four topic areas, the teacher would be said to have consistent *foundationalist* beliefs. These analyses were completed for inservice and preservice teachers separately to determine whether or not there was a difference in consistency depending on experience level. The extent to which consistency categories cross the four topic areas were similar was then completed.

Foundationalist ratings. The first set of Spearman's rho correlations investigated were those between *foundationalist* rankings for preservice teachers over the four content areas for each of the three time points. Table 15 shows all correlations for *foundationalist* items. At Time 1, correlations ranged from -.020 to .242, with no correlations being significant. At Time 2, correlations ranged from .196 to .640, with three correlations being significant. Specifically, the correlation between rankings on items assessing *Weather Patterns* and *Magnets* is .526 (p = .007); the correlation between *Weather Patterns* and *Light* is .457 (p = .022); and, the correlation between *Magnets* and *Plants* is .640 (p = .001). At Time 3, correlations of preservice teachers' rankings of *foundationalist* items were between .001 and .242, with no correlations being significant. For the most part, inservice teachers also did not exhibit significantly correlated beliefs on *foundationalist* items during the time when they took the assessment. Correlations ranged from .010 to .559. Table 16 shows these correlations. Only one of the correlations for *foundationalist* items was significant for inservice teachers. Specifically, rankings of *foundationalist* items for *Weather Patterns* and *Light* were correlated at .559 (p = .030).

Table 15

Spearman's Rho Correlations Between Foundationalist Items for Times 1, 2, and 3.

	Time 1 (N=33)			Time 2 (N=25)			Time 3 (N=48)		
	Weather	Magnets	Plants	Weather	Magnets	Plants	Weather	Magnets	Plants
Magnets	.051			.526**			.066		
Plants	-.101	-.020		.196	.640**		.222	-.133	
Light	-.103	-.106	.242	.457*	.286	.374	.220	.001	.076

* Correlations are significant at the .05 level.

** Correlations are significant at the .01 level.

Table 16

Spearman's Rho Correlations Between Items for Inservice Teachers

	foundationalist			*coherentist*			*reliabilist*		
	Weather	Magnets	Plants	Weather	Magnets	Plants	Weather	Magnets	Plants
Magnets	.078			.109			.432		
Plants	.352	.010		.264	.015		.375	.484	
Light	.559*	.054	.443	-.409	-.044	.272	.345	.617*	.824**

* Correlations are significant at the .05 level.

** Correlations are significant at the .01 level.

N=15

Coherentist ratings. The second set of Spearman's rho correlations investigated were those between preservice teachers' rankings of *coherentist* items for each of the four content areas. Correlations are shown in Table 17 for *coherentist* items. At Time 1, correlations ranged from .075 to .400, with only the correlation between items assessing *Weather Patterns* and *Light* being significant ($r = .400$, $p = .021$). At Time 2, correlations ranged from .322 to .673. Specifically, correlations between *Weather Patterns* and *Plants* ($r = .564$, $p = .003$), *Weather Patterns* and *Light* ($r = .673$, $p < .001$), *Magnets* and *Plants* ($r = .457$, $p = .022$), and *Plants* and *Light* ($r = .428$, $p = .033$) are significant at the .05 level. At Time 3, correlations for preservice teachers' rankings of *coherentist* items ranged from .004 to .261, with no correlations being significant. Inservice teachers also did not exhibit significantly correlated beliefs, with correlations ranging from .015 to -.409. These correlations are exhibited on Table 16.

Table 17

Spearman's Rho Correlations Between Coherentist Items for Times 1, 2, and 3.

	Time 1 (N=33)			Time 2 (N=25)			Time 3 (N=48)		
	Weather	Magnets	Plants	Weather	Magnets	Plants	Weather	Magnets	Plants
Magnets	.132			.322			.071		
Plants	.205	-.149		.564**	.457*		.085	-.017	
Light	.400*	.075	.280	.673**	.367	.428*	.261	.004	.015

* Correlations are significant at the .05 level.

** Correlations are significant at the .01 level.

Reliabilist ratings. The third set of Spearman's rho correlations investigated were those between preservice teachers' rankings of *reliabilist* items for each of the four content areas. Table 18 shows correlations for *reliabilist* items. At Time 1, correlations ranged from -.007 to .313, with no correlations being significant. At Time 2, correlations ranged from .439 to .678. At this time point, all correlations were significant at the .05 level. In fact, four of the correlations were significant at the .01 level. At Time 3, correlations ranged from .103 to .347. Two correlations were significant at this time (*Weather Patterns* and *Light*, $r = .347$, $p = .016$; *Weather Patterns* and *Magnets*, $r = .322$, $p = .026$). On *reliabilist* items, however, inservice teachers exhibited significantly correlated beliefs on two of the six correlations at the .05 level. Correlations ranged from .345 to .824, and are given on Table 16. Specifically, rankings on items assessing the content of *Light* were significantly related to items assessing the contents of *Magnets* ($r = .617$, $p = .014$) and *Plants* ($r = .824$, $p < .000$).

Table 18

Spearman's Rho Correlations Between Reliabilist Items for Times 1, 2, and 3.

	Time 1 (N=33)			Time 2 (N=25)			Time 3 (N=48)		
	Weather	Magnets	Plants	Weather	Magnets	Plants	Weather	Magnets	Plants
Magnets	-.007			.439*			.203		
Plants	.057	.014		.554**	.678**		.103	.210	
Light	.313	.154	-.073	.576**	.547**	.465*	.347*	.322*	.209

* Correlations are significant at the .05 level.

** Correlations are significant at the .01 level.

For the rank-scaled items, there were not enough data to draw conclusions as to the consistency of epistemic belief profiles across time. However, some suggestions can be made as to conclusions. First, it appears that preservice teachers did not exhibit clear beliefs on these items. As it stands, only at Time 2 did the majority of the preservice teachers exhibit consistent beliefs across the four content areas. This is interesting because the sample size at Time 2 is the lowest. On another level, though, this result might be expected. The 25 teachers who participated at Time 2 may be more motivated than the teachers at Times 1 and 3, simply because they participated without being coaxed, prodded, or reminded at length to do so. Thus, they may be differentially motivated than the teachers who participated at other time points. Given the fact that the instrument has been shown to give consistent data over Time 2 for the interns, this suggests the reliability of the scores over time.

Explanations may exist as to the reasons why belief profiles and rankings of the three types of beliefs were not stable over the four topic areas. First, although content validity checks were completed, the content of the rank-scaled items may not match the content taught by the participants. In other words, the teachers participating in this study may not have experience teaching or even thinking about teaching the content assessed by these items given the academic level of the students in their classrooms. Although the items were written to mirror the content assessed in the fourth grade science assessment in the state in which participants taught (Pennsylvania Department of Education, 2002), many of the participants in this study taught students who were in Kindergarten through second grades. Thus, the content of the rank-scaled items may not adequately assess teachers' beliefs.

Second, it is unknown the degree to which each of the epistemic belief frameworks align with what teachers believe about child development (Alexander, Murphy, & Woods, 1996;

Greeno & Gelman, 1989). In other words, teachers may see their students as being differentially able to complete tasks from each of the epistemic frameworks simply because of their cognitive development instead of the teachers' beliefs about effective instruction. They may see students at different grade levels as being differentially able to think abstractly, or to conduct scientific experiments.

Thus, in order to more fully investigate the reliability of the rank-scaled items, domain knowledge measures must be given to participants. These knowledge measures should assess teachers' knowledge of the science content assessed as well as their knowledge of practices appropriate for differential levels of student development. Because of the intimate relations between knowledge and belief (Murphy, 2007), only when knowledge is assessed can these belief rankings be fully interpreted.

Consistency of epistemic belief profiles by content. Preservice teacher's categories of epistemic belief profiles (i.e., *consistent*, *consistent across two frames*, and *mixed*; Tables 10 and 11) obtained from rank-scaled items were also compared across time points to determine the extent to which the assessment produces consistent profiles over time. This was done by comparing profile consistency across times for the consistency of profiles within each topic area. Specifically, chi-square tests of independence were conducted to determine whether profiles were consistent over time. The consistency categories into which each of the profiles fell were analyzed at Time 1 versus Time 2, and again for Time 2 versus Time 3 for each of the content areas separately. Seventeen interns participated at all three time points.

When investigating the content of *Weather Patterns*, there were no significant relations between the consistency of epistemic belief profiles at either Times 1 versus 2 ($\chi^2 = 3.720$, $df = 4$, $p = .538$) or at Times 2 versus 3 ($\chi^2 = 3.648$, $df = 4$, $p = .456$). The complete set of results for

all content areas is located in Table 19. There is evidence, though, that interns are becoming more consistent in their beliefs about the content of *Weather Patterns* over time. Specifically, nine of 17 interns remained in the same consistency category between Times 1 and 2, but two interns moved from the *mixed* category to a more consistent category, and three interns moved from the *consistent across two frames* category to the *consistent* category. Between Times 2 and 3, seven interns remained in the same consistency category, but two moved from *mixed* to a more consistent category and four moved from *consistent across two frames* to having *consistent* beliefs.

Table 19

Consistency of Rank-Scaled Items Within Content Area Across Time.

	Weather Time 2	*Magnets* Time 2	*Plants* Time 2	*Light* Time 2
Time 1				
χ^2 (*p*-value)	3.120 (.538)	3.444 (.486)	3.535 (.171)*	3.975 (.680)
# consistent across time	9	7	5	7
# from *mixed* to more consistent	2	0	6	4
# from *consistent across two frames* to *consistent*	3	4	3	1
Time 3				
χ^2 (*p*-value)	3.648 (.456)	13.126 (.011)	7.579 (.108)	4.303 (.367)
# consistent across time	7	11	11	8
# from *mixed* to more consistent	2	1	2	3
# from *consistent across two frames* to *consistent*	4	3	0	2

Note: In most categories, $df = 4$.

* $df = 2$.

Similar results were found for the other three content areas, with one exception. Specifically, when investigating the relations between the consistency of epistemic belief profiles for *Magnets* at Times 2 and 3, there was a significant relation ($\chi^2 = 13.126$, $df = 4$, $p = .011$). Eleven of the 17 participants remained in the same consistency categories across these two time points.

Participants were also categorized as to the consistency of their epistemic belief profiles for the rank-scaled items. As described previously, ratings given from participants were classified as *consistent*, *consistent across two frames*, and *mixed* as shown in Tables 10 and 11. Analyses of the consistency of categorizations were completed for preservice teachers at all three times, and also for inservice teachers.

Chi-square tests of independence were conducted to determine whether or not epistemic belief profiles for pairs of content areas were consistent at each time point for the interns. Results were similar across all pairs of content areas at all time points. Specifically, the consistency of preservice and inservice teachers' beliefs for one content area was independent of other content areas. Chi-square values and significance levels for this test are included in Table 20.

Table 20

Results from Chi-Square Test of Independence on Pairs of Content Areas for Rank-Scaled Items.

	Time 1 (N=32)			Time 2 (N=20)			Time 3 (N=48)			Mentors (N=15)		
	W	M	P	W	M	P	W	M	P	W	M	P
M	1.976			3.333			7.060			3.012		
	(.740)			(.504)			(.133)			(.556)		
P	1.173	4.676		6.519	1.815		5.166	3.288		4.333	2.333	
	(.883)	(.322)		(.164)	(.770)		(.276)	(.511)		(.363)	(.675)	
L	1.874	1.069	8.341	.704	2.954	1.948	4.577	5.731	1.396	4.333	5.905	4.167
	(.759)	(.899)	(.080)	(.951)	(.566)	(.745)	(.334)	(.220)	(.845)	(.363)	(.206)	(.384)

Note: Numbers in parentheses indicate *p*-value.

df = 4.

The same results were found for the inservice teachers. Specifically, none of the consistency levels for the pairs of content for the inservice teachers were significantly related to each other. However, the results were only based upon 15 people. Thus, the test may not be powerful enough to detect the relations between the content areas.

Thus, whether or not preservice or inservice teachers have consistent belief profiles on one content area does not necessarily mean they will evidence consistent belief profiles in a different content area. This may be due to many reasons. First, the sample size is small. Chi-square analyses are affected by both small and large samples. Because the power to detect differences for these analyses is not high because of the low sample size, there may be content areas that are related, but I am just not able to find those relations in these analyses.

Second, all rank-scaled items are about content in science. "Science" is a large domain, and all four content areas are very different. It may be that teachers have consistent beliefs, but the content areas are too different to be able to give them the opportunity to give evidence of those consistent beliefs. In addition, the content areas assessed may differentially lend themselves to more abstract thinking and use of experiments depending upon the cognitive developmental level of the students being taught (Alexander et al., 1996).

Third, it is possible that despite the content validity checks that were completed, teachers find the pedagogical practices that were provided differentially valuable in their teaching in ways that were not due to epistemic beliefs. In addition, the content may not have been appropriate for all grade levels. On the paper administrations of the survey, two inservice Kindergarten teachers commented in writing that they did not use some of the practices in their teaching because they did not teach the content areas that were assessed by the instrument. Thus, the instrument may

only exhibit validity for teachers in higher grade levels. More research using this instrument is necessary to test these questions.

Convergent Validity of Scores

The second set of research questions addressed convergent validity of scores. The type of convergent validity analyses employed in this study rely heavily on correlational procedures. Factor analysis was not used due to the insufficient sample size. In this particular set of analyses, the data were examined specifically to compare preservice and inservice teachers. Because of the anticipated differences in the professional development and experiences of preservice and inservice teachers, the data were examined for preservice and inservice teachers separately. Based upon these statistical summaries, descriptive comparisons were then made.

2. *Convergent Validity*
    a. To what extent do teachers' reported epistemic frame scores relate to one another?
    b. To what degree are the responses of the various measures developed in this instrumentation system related to one another?
    c. To what extent do teachers' reported epistemic beliefs correlate with their personal epistemology?

The first research question addressed the extent to which the scores obtained on the Likert-type items were related to each other. This is important to investigate because no studies have been conducted on the relations among the three epistemic frameworks investigated here.

The second research question investigated the relations among the profiles obtained from the different types of data for this dissertation. Profiles for four types of data (i.e., Likert-type items, rank-scaled items, descriptions of effective lessons, and video narrations) were obtained in this study. However, relations between the profiles obtained for the rank-scaled items and other

types of profiles were investigated due to the lack of stability of the profiles over the four topic areas assessed by the rank-scaled items. Thus, this research question was addressed by examining the relations among the subscale scores of the Likert-type items with the two types of categorical profiles obtained from teachers' demonstrated pedagogical practices (i.e., profiles from lesson descriptions and video narratives).

The final research question investigates the validity of the instrument relative to external criteria. Specifically, the scores derived from subscales on three previous studies on epistemic beliefs in which scores were established as valid (i.e., Conley et al., 2004; Elby, n.d; & Hofer, 2002) were correlated with the three subscales on the Likert-type assessment. Because the epistemic belief frameworks assessing *foundationalism*, *coherentism*, and *reliabilism* have not been previously investigated, it is unknown whether they measure beliefs similarly to other assessments.

Relations Between Reported Epistemic Frame Scores on Likert-Type Items

In order to determine whether the three belief factors on the newly created instrument assessing *teacher epistemic beliefs* were related to each other, correlations were investigated. Specifically, the three composite scores for each of the factors (i.e., *foundationalism*, *coherentism*, and *reliabilism*) were correlated with each other at each of the data collection time points to determine whether the items were related. Results of these correlations are given in Table 21.

Table 21

Correlations Between Factors on Likert-Type Items at Each Time

	Time 1 Interns (N=33)		Time 2 Interns (N=23)		Time 3 Interns (N=50)		Mentors (N=16)	
	F	C	F	C	F	C	F	C
coherentism	.624*		.892*		.589*		.307	
reliabilism	.517*	.593*	.901*	.919*	.633*	.607*	.402	.476

F = *foundationalist* beliefs; C = *coherentist* beliefs

* Correlations are significant at the .01 level

For preservice interns, results were similar for each of the three data collection times. The three factors were significantly correlated with each other at each data collection time. For example, at Time 1, data from 33 participants were used, and *foundationalist* ratings were correlated with *coherentist* ($r = .624$, $p < .001$) and *reliabilist* ($r = .517$, $p = .002$) beliefs. In addition, *coherentist* and *reliabilist* beliefs were significantly correlated ($r = .593$, $p < .001$). The results at Time 3 were similar, with correlations ranging from .589 to .633 for data from 50 participants. At Time 2, correlations between the three belief factors were higher, ranging from .892 to .919 for data from 23 participants.

The results from inservice teachers, however, are quite different (see Table 21). None of the three belief factors were significantly correlated with each other. Data from all 17 participants was used for this analysis. Ratings of *foundationalist* items were not significantly correlated with either *coherentist* ($r = .307$, $p = .231$) or *reliabilist* ($r = .402$, $p = .110$) beliefs. In addition, *coherentist* and *reliabilist* beliefs were not significantly related to each other ($r = .476$, $p = .054$).

After investigating the relations among diverse epistemic frameworks, it appears that inservice teachers were able to differentiate between the different forms of evidence inherent in the Likert-type questions. This is evidenced by the non-significant correlations between the composite scores. The preservice teachers may not yet have the teaching experience necessary to differentiate between the pedagogical practices assessed by each of the items.

Relations Among Profiles from Different Item Types

Relations between Likert-type items and lesson descriptions. As previously stated, relations between the profiles obtained from rank-scaled items in this survey and those obtained from other types of items were not investigated because the profiles for the rank-scaled items

were not consistent. However, other relations among profiles (i.e., lesson descriptions and video narratives) were investigated. In order to determine whether these measures of demonstrated practices and the measure of reported pedagogical practices were consistent, data collected from participants on the Likert-type items at the first testing administration, or the time in which participants first took the survey, were compared to teachers' demonstrated practices. Specifically, the score profiles established from the Likert-type items were considered to be the primary profiles evidenced by the teachers because the items were content-free.

The composite scores for the Likert-type items were then compared to the composites for *foundationalist*, *coherentist*, and *reliabilist* statements made by the teachers in their descriptions of effective lessons. Chi-square tests of independence were conducted to determine whether or not the epistemic belief profiles for the Likert-type items and the profiles found from the codings of the lesson descriptions were related. This analysis was completed separately for preservice and inservice teachers.

Three categories of epistemic belief profiles for both the Likert-type and lesson description items were found for participants and were used for this analysis. The first profile was for participants who evidenced a *reliabilist* belief. The second was for those who evidenced a *coherentist* belief. The third was for those who evidenced a belief profile that was a mix of the epistemic frameworks. Chi-square tests of independence show that there was not a significant relation between the Likert-type primary profile category and the profile of the category for the lesson description ($\chi^2 = 9.451$, $df = 4$, $p = .051$). However, the relation between these two types of profiles approaches significance at the .05 level. Thus, it appears that there may be a relation between demonstrated and reported pedagogical practices for interns.

The same test was conducted for the inservice teachers. Thirteen inservice teachers provided descriptions of science lessons. These teachers gave evidence of *reliabilist*, *coherentist*, and *mixed* epistemic belief profiles for both Likert-type items and lesson descriptions. As with the preservice interns, chi-square analyses showed no significant relation between epistemic belief profiles for the two types of items ($\chi^2 = 3.250$, $df = 4$, $p = .517$). No patterns were evident in the data. Only four of the inservice teachers evidenced the same belief profiles in their teaching descriptions as they did in their reported practices. Specifically, two teachers evidenced *reliabilist* beliefs for both Likert-type items and the descriptions of their lessons, and two teachers evidenced *mixed* beliefs for both types of data.

There are multiple reasons that the relation may not be significant. First, the statistical test is based upon data collected from only 38 participants. Because of the smaller sample size, there may not be enough statistical power to detect differences. Second, data from preservice teachers for this test was collected at the first testing administration. The preservice teachers may not have had enough experience teaching at that time. Significant relations may have been found between reported and demonstrated practices if the data was collected when the interns had more teaching experience.

Again, the lack of significance in the data from the mentor teachers may be due to the small sample size. Only 13 inservice participants provided enough of a written description for their epistemic belief profiles to be compared. Further testing is needed to determine whether inservice teachers' reported and demonstrated practices align.

Relations between Likert-type items and video narratives. Convergent validity of the instrument was also assessed using another measure of demonstrated practices available from preservice participants. As part of a course assignment in their science methods course in Fall

2006, preservice teachers were required to teach and videotape a three-lesson sequence in science. They then compiled and narrated a 10-minute video comprised of the best evidence they had that their students acquired the instructed content. In the narrations, the preservice teachers were required to address the objectives of the lessons, as well as give descriptions of the lesson activities.

Interns who participated at both Times 1 and 2 in a timely fashion were asked by the researcher for use of their videos with the hope that participants with differing epistemic frame profiles would be sampled. Videos from five preservice participants were used for this study. These five preservice teachers were used in this study because they were the only five who gave permission to use their videos. It was hypothesized that preservice teachers may not exhibit the same epistemic belief profiles in their demonstrated practices as they do in their reported practices. This is likely due to the fact that the videos the preservice teachers created were completed at the beginning of their student teaching experience when they did not have as much knowledge about what teaching practices work in the classroom. In order to gain an understanding of how preservice teachers' pedagogical practices reflect the epistemic frameworks, the narrations of the videotapes were transcribed. The transcripts were then broken down into idea units and analyzed as to whether they reflect the epistemic frameworks. This was done in the same way as for the constructed-response questions. Composites of the number of sentences representing each epistemic position were made.

Three interns who allowed access to their videos evidenced a *reliabilist* epistemic belief profile as their primary profile. These three participants also evidenced a *reliabilist* perspective in their science videos. Table 22 provides counts of the number of statements from the video evidencing the different epistemic belief frameworks.

Table 22

Counts of Statements Made by Interns in the Narration of Their Science Videos.

	Likert-type Profile	Narration Profile	Non-codable statements	*foundationalist* statements	*coherentist* statements	*reliabilist* statements
Participant 1	CR	R	23	2	6	22
Participant2	R	R	56	6	2	15
Participant 3	FCR	FCR	23	6	6	6
Participant 4	R	R	35	1	3	10
Participant 5	R	R	31	0	4	7

This was not unexpected, as the focus of the science education course for which the videos were made emphasized inquiry-oriented instruction with hands-on experiments. Examples of statements made in the narration by these interns are given below.

- "Over the three days, students were engaged in scientifically oriented investigations in order to collect evidence to answer a driving question, which I posed to the students."
- "The students were asked to draw a prediction of what they thought would be in the flashlight and what makes a flashlight turn on."
- "After all their times had been recorded, the students analyzed their data by answering questions about which situation evaporated the water the fastest."

One of the interns evidenced a primary epistemic belief profile that was consistent across two frameworks, *coherentism* and *reliabilism*. In the videos, however, this intern used a *reliabilist* framework almost exclusively. Again, this may not be unexpected given the nature of the science education course for which the videos were made. An example of a *reliabilist* statement made by this intern is given below.

- "They described tests that they had tried using ooblick and what state of mater they believed it to be based on the evidence from their tests."

The final intern evidenced a *mixed* epistemic belief profile as her primary profile. Surprisingly, given the nature of the science education course, she also evidenced a *mixed* epistemic belief profile in the narration of the video. Six statements from this participant were coded as evidencing each of the epistemic belief frameworks in the narration given by this intern. An example of a statement from the intern evidencing each framework is given below.

- *Foundationalist*: "Today, I wanted to introduce to the students that earthworms are decomposers."
- *Coherentist*: "Right now, in science, we're learning about food chains, and I wanted to be sure to connect my 'Exciting Earthworms' lesson to food chains…."
- *Reliabilist*: "I did this so that the students could compare what was occurring in their terrariums with what was occurring in mine."

Overall, four of the five interns evidenced a *reliabilist* profile for the narration on their teaching videos. In addition, four of the five interns evidenced the same epistemic belief profile in the narration as their primary profile. Thus, it appears that preservice teachers are evidencing similar beliefs in their teaching as they are reporting in the Likert-type items. In addition, the beliefs evidenced in the narrations of their teaching were able to be categorized in a way that these relations could be found, giving evidence of the concurrent validity of the measure. These two measures of beliefs may also be similar because the teachers have already contextualized their beliefs into their teaching (e.g., Collins, 1992; di Sessa & Cobb, 2004). They were not being asked to rate content they have never taught or have no experience with teaching. Instead, the preservice teaches were intimately familiar with the content they are teaching. Thus, they were able to link their belief and knowledge in such a way to evidence their beliefs in their pedagogical practices.

This evidencing of beliefs was particularly noticeable with the preservice teacher who had *mixed* belief profiles for both the Likert-type items and the video narrations. Although the content of the science education course was heavily inquiry-oriented, this participant gave evidence of a *mixed* belief framework in her teaching. Thus, because she felt that *foundationalist*,

coherentist, and *reliabilist* beliefs were all important, she was able to use all of them in her teaching.

Relations Between the New Instrument and Scores on Previously Validated Instruments

To answer the final research question, the relations between data from the scores derived from the subscales on the Likert-type items and other instruments assessing the use of evidence found in the personal epistemology literature (i.e., Conley et al., 2004; Elby, n.d.; & Hofer, 2002) were investigated. Composite scores for each of the epistemic belief factors represented by items from these three instruments were calculated from these items were compiled in the same way as for the Likert-type items in the newly created instrument and descriptive statistics for these composite scores are given in Table 23. Pearson correlations between the composite scores on the measure of personal epistemology and the Likert-type items in the newly created measures were calculated to determine whether or not these two types of beliefs are related. It is unknown whether the measures of epistemic beliefs in the newly created instrument were correlated with the measures of epistemic beliefs from previously validated instruments. However, Conley et al. (2004) appear to be assessing a *reliabilist* framework; therefore, it was hypothesized that the composite score for *reliabilist* beliefs as assessed in the newly created instrument were correlated significantly with the composite score on Conley's *Justification* factor.

Table 23

Descriptive Statistics for All Administrations of the Previously Published Justification Items

	Time 1 Interns (N=33)		Time 2 Interns (N=20)		Time 3 Interns (N=50)		Mentors (N=16)	
	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s
All participants								
Conley et al. (2004)	55.79	4.470	55.15	4.452	54.92	6.359	58.25	3.841
Elby (n.d.)	19.79	3.959	19.40	2.604	21.92	5.551	18.33	3.651
Hofer (2002)	17.09	2.930	16.50	1.850	17.28	4.857	17.42	3.630
Interns who participated at all times (N=17)								
Conley et al. (2004)	55.25	4.359	55.13	4.500	54.69	8.412		
Elby (n.d.)	19.31	3.683	19.38	3.052	22.19	5.695		
Hofer (2002)	16.25	3.000	16.31	1.922	17.44	5.416		

For the nine items assessing Conley et al.'s (2004) *Justification* factor, Cronbach's alpha reliabilities for the scores obtained at each of the three time points ranged from .672 to .701 (see Table 13 for all Cronbach's alpha values). For the scores obtained from the five items assessing Elby's (n.d.) factor assessing beliefs about the nature of knowledge and evidence, Cronbach's alphas ranged from .079 to .667. For the scores obtained from the four items assessing Hofer's (2000) factor assessing personal justification, Cronbach's alphas ranged from .216 to .653. This result was not unexpected, though, as many of the instruments assessing personal epistemology have either only been used by one researcher, or do not give stable results in multiple investigations (e.g., Jehng et al., 1993; Qian & Alvermann, 1995). As with the preservice interns, Cronbach's alphas for these three epistemic belief factors from scores from interns were not very high. Alpha for scores from Conley et al.'s (2004) factor was .658, for Elby's (n.d.) factor was .444, and was .758 for Hofer's (2000) factor.

Correlation coefficients between these three factors and the three factors evidenced by the Likert-type items were calculated separately for Times 1, 2, and 3, and also were calculated separately for preservice and inservice teachers. For preservice teachers at Time 1, the scores from items assessing *Justification* factor on Conley et al.'s (2004) instrument were significantly correlated with *foundationalism* ($r = .415$, $p = .016$), *coherentism* ($r = .360$, $p = .040$), and *reliabilism* ($r = .493$, $p = .004$). No other correlations were significant. All correlations are presented in Table 24.

Table 24

Correlations Between Factors on Likert-Type Items and on Factors on Previously Published Items from Interns.

	Time 1 (N=33)			Time 2 (N=20)			Time 3 (N=50)		
	Conley	Elby	Hofer	Conley	Elby	Hofer	Conley	Elby	Hofer
Foundationalist	.415*	-.081	-.033	.379	.124	.181	.262	.313*	.166
Coherentist	.360*	.022	.011	.563**	-.163	.284	.497**	.038	.101
Reliabilist	.493**	-.200	.012	.702**	-.154	.229	.474**	.120	.085

Note: Correlations are based upon ten items for *Foundationalist*, *Coherentist*, and *Reliabilist* factors, nine items for the Conley et al. (2004) factor, five items for the Elby (n.d.) factor, and four items for the Hofer (2000) factor.

* Correlations are significant at the .05 level.

** Correlations are significant at the .01 level.

For Time 2, the scores from the Conley et al. (2004) factor were significantly correlated with scores from both *coherentism* ($r = .563$, $p = .010$) and *reliabilism* ($r = .702$, $p = .001$). Scores were not significantly correlated with any other factors, and are all presented in Table 24. At Time 3, scores from the Conley factor were again significantly correlated with *coherentism* ($r = .497$, $p < .001$) and *reliabilism* ($r = .474$, $p = .001$). In addition, scores obtained from items assessing *foundationalism* were significantly correlated with scores obtained on items from Elby's (n.d.) instrument ($r = .313$, $p = .027$). The rest of the correlations were not significant, and are presented in Table 24.

Data from the factors on the three previously validated instruments and the three factors on the newly created instrument were also collected from inservice teachers and were correlated to determine whether or not there were relations between the factors. Correlations ranged from -.034 to .278. None of the correlations were significant for the data collected from the inservice teachers. These correlations are presented in Table 25.

Table 25

Correlations Between Factors on New Instrument and on Factors on Previously Published Items from Inservice Teachers.

	Conley et al. (2004)	Elby (n.d.)	Hofer (2000)
Foundationalism	.163	.252	.045
Coherentism	.071	-.050	.264
Reliabilism	.278	.227	-.034

N = 12

The results of these analyses show that there may be some relation between scores established on the new instrument and scores from previously published instruments assessing epistemic beliefs. Specifically, scores from the Conley et al. (2004) instrument assessing justification were significantly correlated with preservice teachers' scores at all three time points with scores from items assessing both *coherentism* and *reliabilism*. No other correlations were consistently significant.

As previously mentioned, it is not surprising that the Conley factor and the *reliabilist* factor are significantly correlated. Participants rating items are asked about collecting data through experiments and observations in both factors. On a surface level, they seem to be very similar. It is somewhat surprising, however, that the Conley factor was significantly correlated with items assessing *coherentism*. These items do not appear to be similar on a surface level. It is possible, though, that teachers may have rated these similarly because when an experiment is designed, there are a number of factors that contribute to the results. For example, the connections inherent in *coherentism* may reflect the number of factors teachers see as contributing to experiments. The fact that the inservice teachers did not exhibit these relations may be due in part to the fact that the sample size is too small. However, the correlations were not high, suggesting that the inservice teachers may have been better able to distinguish between the different types of items because of their experience level. Another possible reason for fact that preservice teachers evidenced a relation between *coherentism* and Conley et al.'s (2004) justification factor is because the content assessed by Conley and her colleagues is about science education. This association may be an artifact of the content assessed in the items. Specifically, the items assess beliefs about the use of observable evidence collected through science experiments. Possibly unlike the inservice teachers, the education of the preservice teachers has exposed them to the need to think about all possible confounds that may contribute to the results

of a scientific experiment. Taking into account the links between a number of confounds may lead preservice teachers to relate these items to *coherentist* beliefs.

CHAPTER 5

FINDINGS, CONCLUSIONS, AND IMPLICATIONS

This dissertation study has focused on the measurement of *teacher epistemic beliefs.* The final chapter of this dissertation will overview the present study and relevant findings. Specifically, in this chapter the problem statement, methodology, analysis, and results will be summarized. Following the summary of the investigation, implications for research will be forwarded. Finally, several avenues for future research will be explored.

Summary of the Investigation

Review of the Problem

The study of epistemology has solid literature bases in both philosophy and educational psychology. Although researchers from both areas define epistemology as the study of the nature of knowledge and knowing (Pollock & Cruz, 1999), scholars from these two areas have employed diverse methods for operationalizing and investigating the question of what it means to *know*.

For example, philosophers have used logical arguments to deduce the nature of the conditions that should be used to justify knowledge in their study of epistemology (e.g., Kvanvig, 1986a; Shogenji, 2001). From these rational speculations (Alexander, 2006), three prominent epistemic frameworks (i.e., *foundationalism*, *coherentism*, and *reliabilism*) have emerged. What differentiates each of these frameworks are the conditions necessary for the justification of knowledge. These three epistemic frameworks present justification conditions that are particularly applicable to education (Murphy et al., 2007). Although much work using logical arguments to deduce different acceptable justification conditions has been completed by philosophers, these frameworks have not been investigated using the measurement techniques forwarded in the psychological literature.

Researchers within the educational psychology community have investigated epistemology in ways that vary from the more analytically-oriented philosophers. Although philosophers have been interested in the nature of knowledge itself, psychologists have been interested in the diverse beliefs people have about that knowledge. More specifically, they have investigated the ways in which people come to know, and their beliefs about how people come to have knowledge. These beliefs have been studied in diverse ways by researchers, and the results of their investigations have lead to unidimensional and multidimensional conceptualizations of knowledge beliefs. Researchers have also investigated the extent to which these beliefs about knowledge are domain-general or domain-specific. In general, participants in these studies have consisted of undergraduate students (e.g., Hofer, 2000; Perry, 1970; Schommer, 1990) or adults with diverse occupations and educational levels (e.g., Belenky et al., 1986; Schommer, 1998). Such beliefs about knowledge have been investigated primarily with interviews or Likert-type items. In addition, the measures of epistemic beliefs used in this literature have exhibited relatively unstable factor structures (Hofer & Pintrich, 1997). Interestingly, however, few investigations have explored the epistemic beliefs of teachers despite the influential role they have in student learning and the formation of student beliefs (Hofer, 2001). Consequently, it is imperative to measure and investigate the role of *teacher epistemic beliefs* in the learning process.

Procedures

For this dissertation study, a new instrument assessing *teacher epistemic beliefs* was developed and the psychometric properties of scores resulting from the use of this instrument, including reliability and convergent validity, were investigated. In this section, a description of the sample and instrument will be given. Specifically, the participants are described, instrument

design and content validity are reviewed, as are the procedures employed to collect data in this study.

Sample and procedures. To begin the study of *teacher epistemic beliefs*, data were collected from both elementary preservice and inservice teachers. Participating preservice and inservice teachers were involved in a Professional Development School program (PDS) characterized by the partnership between a large land-grant university and the local school district. Preservice teachers participating in this study were completing a year-long internship in conjunction with a PDS teacher preparation program in classrooms ranging in age from Kindergarten to fifth grades. Upon successful completion of the program, these preservice teachers will be certified to teach in Kindergarten through the sixth grades. Preservice teachers (N=61) were enrolled in the PDS, and all were asked to participate in the study at three time points. Overall, 54 preservice teachers (88.5%) participated in at least one data collection point. For the first two time points, participants responded to the survey online using the Survey Monkey website. For the final data collection time, preservice teachers were asked to respond to the survey on paper during a regularly scheduled meeting.

Inservice teachers (N=61) were also asked to participate in the study. The inservice teachers taught students in grades Kindergarten through five and were involved in the PDS as mentor teachers for the preservice interns. The response rate for the inservice teachers was 28%. Inservice teachers were asked to participate in the study at two time points, with the first being online using the Survey Monkey website and the second being on paper. Due to the low response rate and inability to get teachers to respond to the instrument at more than one time point, the data collected across the two time points were collapsed for the analysis.

Instrument design. For this dissertation study, a new instrument assessing *teacher epistemic beliefs* was developed. The instrument was designed to examine teachers' beliefs about

justification and evidence as would be realized in their pedagogical practices. The instrument was designed to assess beliefs in multiple ways. Specifically, two types of items were developed including Likert-type and rank-scaled items. Thirty Likert-type items were developed with ten items assessing each of the three epistemic frameworks described previously. The items were content-free. In other words, they were designed to describe pedagogical practices that could be used by the teachers across a number of content areas. Items were purposefully written with parallel wording across the three epistemic frameworks to ensure the language used in the items did not influence participants' responses.

Rank-scaled items were also written to assess teachers' beliefs about the pedagogical practices that would evidence different epistemic belief frameworks. Twelve items were written assessing different pedagogical practices (i.e., instructional activities, informal assessments, and cues or prompts) that are common in classrooms. The items consisted of three pedagogical practices each evidencing one of the three epistemic belief frameworks discussed previously. Participants were asked to rank these pedagogical practices in the order that they were important for use in their classrooms. Unlike the Likert-type items, the rank-scaled items were not free of content. Instead, these items were written to reflect four basic science concepts (i.e., *weather patterns*, *magnets*, *plants*, and *light*) that align with the fourth grade science standards and assessments (Pennsylvania Department of Education, 2002). Items reflecting the three categories of pedagogical practices (e.g., assessments) were written for each of the four science concepts (e.g., *magnets*). For every item, three choices for pedagogical practices were written, each reflecting one of the three epistemic frameworks previously outlined. For these items, participants were asked to rank the three choices in order of their importance in their teaching without ranking the choices as being tied.

Content validity. The content validity of the Likert-type and rank-scaled items was assessed in two ways. First, the degree to which each of the items reflected the three epistemic frameworks was assessed. Doctoral students enrolled in a course on the role of knowledge and beliefs in teaching and learning studied the three epistemic frameworks used in this study as a regular part of their course curriculum. Having discussed and reviewed content and readings on each of the philosophical frameworks, the doctoral students were asked to read each of the items comprising the two parts of the instrument and to identify the epistemic belief framework they thought was assessed by each item. Modifications to the instrument were made based upon the responses of the doctoral students so that the items would reflect the frameworks in a way that was understandable and identifiable.

The validity of the pedagogical practices and science content was also assessed. Experts in teacher education and science education were asked to examine the extent to which the practices and science content were appropriate for elementary school settings. Based on the recommendations of these experts, modifications were made to the instrument so that it more accurately reflected the practices and content of an elementary classroom.

Research Questions

Several research questions regarding the psychometric properties of the newly created instrument were assessed in this study. These questions related to the reliability and validity of scores obtained from the instrument. These questions are given below.

1. *Reliability*
    a. To what extent are teacher epistemic frame profiles consistent across item type and within selected pedagogical practices?
        i. To what degree can belief profiles be identified for Likert-type items?

ii. To what degree can belief profiles be identified for each epistemic framework across science content areas on the rank-scaled items?

iii. To what degree can descriptions of lessons given on the constructed-response items be rated similarly by independent raters?

b. To what extent does the instrument produce internally consistent scores to assess *teacher epistemic beliefs* as measured by the Likert-type items?

c. To what extent does the instrument provide stable scores of *teacher epistemic beliefs* as measured by the Likert-type items?

2. *Convergent Validity*

a. To what extent do teachers' reported epistemic frame scores relate to one another?

b. To what degree are the responses of the various measures developed in this instrumentation system related to one another?

c. To what extent do teachers' reported epistemic beliefs correlate with their personal epistemology?

Findings and Conclusions

Reliability

Development of belief profiles. In the present study, the epistemic belief profiles of teachers were created in a number of ways. First, belief profiles were created for teachers based on their responses to the Likert-type items. Composite scores were created for each of the three epistemic frameworks by adding participants' response scores to all items evidencing each framework. Profiles were then created by investigating of the margin of error at each data collection point. Specifically, the margin of error for all composite scores at each data collection point was found. This value was used as a cut-off point to determine whether teachers evidenced significantly different scores on each of the three frameworks. For example, if the scores on two

epistemic frameworks were different by more than the margin of error, then it was concluded that the teacher rated those two frameworks significantly different from each other. From the data collected, three different epistemic belief profiles were identified for both the preservice and inservice teachers. Over all time points, three profiles of teachers' beliefs resulted from this investigation. The first group of teachers evidenced a *reliabilist* profile, rating *reliabilist* items significantly higher than items from the other two frameworks. The second group of teachers evidenced a *coherentist* profile, rating *coherentist* items significantly higher than items from the other two frameworks. The final group of teachers evidenced a *mixed* epistemic belief profile. These teachers did not rate one group of items as significantly higher than the other two groups of items. These three epistemic belief profiles were found for both preservice and inservice teachers at all data collection points.

Second, epistemic belief profiles were identified for each topic area (e.g., *light*) for the rank-scaled items. Rankings were summed across the three epistemic frameworks for each topic area to create composite score profiles. The consistency and belief profile for the teacher's rankings was then determined based upon the pattern of the composite score profile. As with the Likert-type items, preservice and inservice teachers evidenced three belief profiles for each of the topic areas assessed using the rank-scaled items. Similar to the results of the Likert-type items, teachers evidenced beliefs that were *foundationalist*, *coherentist*, or *mixed* in nature.

Finally, epistemic belief profiles were also developed based upon data collected from lesson descriptions generated by teachers and narrated teaching videos solicited from five preservice teachers. The lesson descriptions and narrations were coded at the sentence level. Each sentence was coded separately as being representative of one of the epistemic three frameworks. To establish inter-rater agreement, two raters coded ten percent of the lesson descriptions independently. After the reliability of the coding scheme was established by the high

inter-rater agreement (88% agreement in coding), profiles of teachers' beliefs were developed. In order to determine the epistemic belief profiles evidenced in their demonstrated practices, the total number of sentences evidencing each of the three epistemic frameworks were calculated. Profiles of teachers' beliefs were compiled for the lesson descriptions and narratives using an investigation of the margin of error previously described. As with the other types of data collected, participants evidenced either *foundationalist*, *coherentist*, or *mixed* epistemic beliefs.

Reliability of Likert-type items. Reliability of the Likert-type items was assessed in classically accepted ways as well as in ways that were novel. The internal consistency for the three individual factors was high for preservice teachers, ranging from .665 to .808 for *foundationalist* beliefs across the three times; from .823 to .887 for *coherentist* beliefs across the three time points; and, from .774 to .873 for *reliabilist* beliefs across the three times. Cronbach's alpha was lower for inservice teachers, ranging from .676 to .731 across the three belief factors when the data were collapsed across time. Cronbach's alpha was consistently lower for scores from items assessing *foundationalist* beliefs than for scores from the other two frameworks. Reliability for the preservice teachers increased over time, which provides evidence that the interns were becoming more consistent in their ratings of the items over time. This may be due, in part, to the fact that they were gaining more actual teaching experience, and were rating the items based upon whether or not the practices worked in their classrooms.

These results may give some evidence that preservice teachers are beginning to be able to implement their beliefs about effective pedagogical practices within the context of a classroom. They are beginning to be able to identify similarities between practices, and they rate practices from each of the epistemic frameworks more consistently over time. Thus, they have more experience in what works in their classrooms, and they are better able to rate their beliefs accurately. This would increase the reliability of the scores.

Although it appears that more experience with teaching may lead to higher score reliability, the question of lower reliability in the inservice teachers' scores arises. This, however, may be explained by the low sample size. Only 16 of the 17 inservice teachers responded to all 30 Likert-type items. Increasing the sample size may increase the reliability of the scores. Thus, this is a question for future research.

In addition, the stability of ratings on the Likert-type items was assessed for the preservice teachers over time. Correlations between *foundationalist* composite scores ranged from .331 to .490, from .542 to .686 for composite scores for *coherentist* items, and from .256 to .536 for composite scores for *reliabilist* items. Most of these correlations were significant, suggesting that the instrument produces scores that are stable over multiple implementations of the assessment.

Correlations, however, were not high. This may be due to the fact that the preservice teachers were still acquiring hands-on experience in classrooms. With the exception of one correlation, the correlations between composite scores assessing *foundationalist* beliefs were lower across the three time points. This result mirrored the results of the internal consistency reliabilities. *Foundationalist* beliefs may have the lowest reliability because they were not endorsed as much by the teachers. In other words, *foundationalist* beliefs were only rated highly by teachers having *mixed* profiles; they were not rated highly individually. This may have been due to the training of the preservice teachers. Their training was inquiry-oriented, which emphasizes experimentation by their students so they can determine their own answers to questions. *Foundationalist* beliefs emphasize that there are beliefs central to all other beliefs (Fumerton, 2000), which may be in contrast to inquiry-oriented instructional methods.

The stability of preservice teachers' belief profiles over time was also assessed using chi-square tests of independence. Although the relations between belief profiles were not significant

across time, the relations approached significance between Times 2 and 3. Thus, although the correlations were not high, preservice teachers gave evidence that their belief profiles are beginning to stabilize over time. In fact, one-third of the participants shifted from the *mixed* belief category to a profile where only one epistemic framework was rated highly. Again, this may be due to their increasing experiences as teachers. Specifically, preservice teachers who were later in their student teaching experiences have begun to contextualize their teaching beliefs with their practices (e.g., Collins, 1992).

Reliability of the rank-scaled items. Although the internal consistency and stability reliability scores from the Likert-type items were strong, the reliability for the rank-scaled items was less than desirable. The internal consistency for these items was determined separately for each time point for preservice and inservice teachers using Spearman's rho correlations. Rankings for *foundationalist*, *coherentist*, and *reliabilist* items were investigated separately. At each time point, correlation coefficients were calculated between the composite rankings for each of the content areas. Higher correlations between the rankings evidenced beliefs that were more consistent across topic areas. For *foundationalist* items, only four correlations between the topic areas were significant, with three significant at Time 2 for the preservice teachers and one for inservice teachers. For *coherentist* items, six of the Spearman's rho correlations across the topic areas were significant, with four of these six relations being significant for preservice teachers at Time 2. For *reliabilist* items, all correlations between data collected from preservice teachers for the four topics were significant at Time 2. Other correlations were also significant for both samples.

With the exception of preservice teacher rankings at Time 2, few of these correlations are significant across topic area. There are some reasons as to why this may have occurred. First, preservice teachers who participated at Time 2 may have been more motivated to participate in

the study and show what they know about teaching than preservice teachers at the other two time points. These teachers participated in the study a second time without being repeatedly asked or reminded. This suggests that those participants who are motivated to complete the survey may have more consistent beliefs. This, however, might be because they want to show the researchers that they are good teachers and so they were motivated to rank the items in ways they thought fit with what they were being taught. This remains a question for future research.

Explanations do exist as to why the rankings for each of the epistemic frameworks may not be consistent over time. First, although content validity checks were performed, the content of the rank-scaled items may not match the curriculum taught in the teachers' classrooms. Preservice and inservice teachers may not have experience teaching or even thinking about content they do not teach in their classrooms. Thus it is questionable how much knowledge they have about not only the content of the rank-scaled items, but also about the pedagogical practices they would need to use to teach students the content. Because the rank-scaled items were written using fourth grade science standards (Pennsylvania Department of Education, 2002) as a guide, the assessment may be more appropriate for third and fourth grade teachers than it is for teachers who have students in lower grades. Further investigations should be conducted to answer this question. Second, it is unknown what teachers believe are appropriate pedagogical practices for students at different developmental levels. Teachers may see younger students as being differentially able to complete the pedagogical practices assessed by the rank-scaled items. Further investigation assessing teachers' knowledge of child development and science content is necessary to answer these questions.

The consistency of preservice teachers' belief profiles by content area was also investigated over time. In general, the rank-scaled items did not exhibit the same stability as the Likert-type items with this preservice teacher sample. Specifically, preservice teachers had

different levels of consistency in their rankings over time. Again, this may be due to the lack of content validity of the items. Although content validity checks were completed, teachers may lack knowledge of the specific topics assessed by the rank-scaled items. The preservice respondents may not teach those topics in their classrooms, giving them few opportunities to think about the pedagogical practices they may use.

Convergent Validity

Relations among epistemic framework composites. In order to investigate the convergent validity of the *teacher epistemic belief* instrument, the relations between the epistemic framework composites were explored. Correlations between the composite scores on the Likert-type items were examined separately at each data collection point. Results for the preservice and inservice teachers varied. At each of the three time points, preservice teachers exhibited significant correlations between composite scores assessing *foundationalist*, *coherentist*, and *reliabilist* beliefs. These correlations ranged from .517 to .624 for Time 1, from .892 to .919 for Time 2, and from .589 to .633 for Time 3. All were significant at the .01 level, regardless of the data collection time period. The inservice teachers, on the other hand, exhibited no significant correlations between these beliefs. Thus, it appears that the experience level of the inservice teachers contributed to their ability to differentiate between the three different epistemic belief frameworks. The preservice teachers were not able to differentiate between the items, suggesting that experience level plays a large role in the identification of beliefs.

Relations between composite scores and demonstrated practices. The epistemic belief profiles exhibited on the Likert-type items were compared to teachers' demonstrated teaching practices using chi-square tests of independence. Belief profiles obtained from teachers' lesson descriptions were compared for both preservice and inservice teachers. Results were not significant for either group of participants, but approached significance for preservice teachers. It

is possible that significance could have been achieved in the data collected from preservice teachers. However, the preservice teachers were asked to provide descriptions of their lessons at the first testing time. Thus, they may not have had the experience necessary to be able to identify their beliefs about effective practices, or how to put those beliefs into practice at the beginning of their teaching experiences. Surprisingly, however, inservice teachers showed similar results. There were no relations between the descriptions of their lessons and their epistemic belief profiles as evidenced by the Likert-type items. This may be due to the limited sample size; only 13 inservice teachers gave descriptions of effective lessons. In addition, the effort expended by the teachers, both at preservice and inservice levels, may not have been adequate enough to produce responses that described the details of their lessons in such a way that they accurately reflected their epistemic beliefs. Thus, further research should be conducted to determine whether lesson descriptions and the Likert-type items produce similar epistemic belief profiles.

Relations between the epistemic belief profiles evidenced by the preservice teachers in their videos, however, were remarkably similar to the belief profiles they evidenced in the Likert-type items. Specifically, four of the five interns who allowed access to their science videos exhibited identical belief profiles for the two types of data.

Although the sample size was small, this is a very strong result. Specifically, this result suggests that preservice teachers are able to evidence their epistemic beliefs in their teaching. This result also suggests that Likert-type items on the newly created *teacher epistemic belief* instrument are designed in a way that they are able to assess teachers' epistemic beliefs in the same way they would be evidenced in the classroom. In other words, preservice teachers' espoused epistemic beliefs aligned very well with their enacted beliefs. Because the videos were completed for a class assignment, the preservice teachers were much more thorough in the narrations of their lessons than they were in the lesson descriptions they wrote for this study. It

may be that similar epistemic beliefs were evidenced by the teachers in the actual lessons they described for the study, but that the descriptions of the lessons may not have been thorough enough capture the epistemic beliefs of the teachers using the coding system employed. Different methodologies, such as the use of think-alouds or the collection of lesson plans, may produce data that is more reflective of the pedagogical practices of teachers and, thus, of their epistemic beliefs.

Relations to scores on previously validated instruments. The final assessment of convergent validity involved investigating the relations between the composite scores from the Likert-type items and the scores on factors from previously validated instruments assessing epistemic beliefs. Specifically, three instruments were selected from the literature as assessing the justification of knowledge in some way (i.e., Conley et al., 2004; Elby, n.d.; & Hofer, 2002). Those items from these three studies that assessed how justification was used were given to participants. Correlations among composite scores from these Likert-type items and the composite scores from the three factors from the personal epistemology instruments were calculated.

Preservice teachers' scores on Conley et al.'s (2004) justification factor were significantly related to their scores for *coherentist* and *reliabilist* beliefs at all three time points. It is not surprising that *reliabilist* items were significantly related to Conley et al.'s (2004) justification factor because these items are about collecting data through experiments and observations. What is surprising is that these items were also related significantly to *coherentist* items. The significance in the correlations between the justification factor and the *coherentist* factor may be due to the fact that teachers understand that when designing experiments, a number of competing factors and explanations for the results must be taken into account. The design of the experiments themselves may be evidencing a *coherentist* framework for these

teachers simply because of the connections between the diverse factors in designing the experiments. This result may also have occurred because the curriculum used in the school district where the participants taught emphasizes connections among concepts (State College Area School District, 2006). However, neither of the other two instruments assessing justification were significantly related to the factors on the newly created instrument.

Data collected from inservice teachers, however, exhibited different results. Specifically, none of the data for any of the factors were significantly related to each other. In addition, the correlations are very small, ranging from -.050 to .278, suggesting that inservice teachers may be more developed in their ability to differentiate between pedagogical practices. They may have the teaching experience necessary to differentiate between the pedagogical practices inherent in the newly created instrument and the items assessing justification from the previously validated instruments. These types of justification may be only subtly different, but the inservice teachers were able to pick up on those variations in justification.

Implications for Educational Research

There are a number of implications that can be forwarded as a result of this study. The first pertains to the survey administration. In all but the final testing administration, the instrument was given to the preservice teachers in an online format. During the final administration, the survey was given as a paper-and-pencil measure. The response rate for the interns was much higher at the third time point. This is likely due to the fact that the data were collected during a regular meeting period for the PDS. Moreover, the online administration, on the other hand, did not allow for contact between the researcher and the participants. In addition, interns were reminded several times to complete the survey online. Subsequent administrations of the survey should be given to preservice teachers in a paper-and-pencil format to facilitate data collection. If the survey is given during regular meeting times, more preservice interns may

respond multiple times, allowing for testing of the changes in their beliefs over time. This finding is contradictory to what was expected. That is, it was expected that the online format would give the time-stretched preservice teachers the opportunity to complete the survey at their own convenience. The reality, unfortunately for the present study, was that inevitably the teachers had many more pressing commitments. This also may be due to the fact that the survey was given at the end of the year. If given at the beginning of the school year, teachers may be more willing to participate.

Many inservice teachers failed to respond to the survey regardless of the data collection format. As was the case with the preservice teachers, this is likely attributable to the fact that the inservice teachers are very busy in their classrooms and do not feel they have the extra time to fill out a survey. The lack of response at multiple time points suggests that inservice teachers may feel that although they took the time to respond to the survey once, they do not feel it is necessary to respond a second time. In future research, it would be advisable to offer these teachers an incentive for their time. This incentive could be monetary or could be something as simple as a donation of supplies for their classroom. The addition of an incentive may increase the participation of the inservice teachers.

Although the response rate was less than adequate over the multiple administrations of the survey, a second, important implication can be forwarded. That is, it is possible to develop profiles of *teacher epistemic beliefs* using the instrument created for this dissertation study. The use of these epistemic belief profiles could have profound implications for education. Specifically, the results of this study show that preservice teachers espouse the same epistemic belief profiles that they evidence in their classroom teaching. As Hofer (2001) speculated, teachers' epistemic beliefs do influence their pedagogical practices. Although this dissertation did not study beliefs in a causal way, the finding that teachers espouse the same beliefs as they

demonstrate in their pedagogical practices could have major implications for teacher educators. For example, if the practices a preservice teacher employs in the classroom are not working effectively, it is possible that their beliefs about practices may be a reason as to why they are choosing to employ those practices. Teacher educators can then investigate the beliefs of the teachers underlying their choices of pedagogical practices rather than try to change the practices without changing the beliefs connected to those practices.

One finding that is particularly interesting is that no teachers exhibited primarily *foundationalist* beliefs. This may be due to the training of the preservice teachers. They are trained using inquiry-oriented methods, which is very similar to a *reliabilist* framework. This training may be part of the reason why teachers were less likely to endorse *foundationalist* beliefs. In addition, the curriculum employed in the district emphasizes the connections between the content (State College Area School District, 2006), which, in turn, de-emphasizes the belief that some knowledge is foundational to other pieces of knowledge. Preservice teachers also may be beginning to develop a schema for teaching, resulting in the increase in *coherentist* beliefs over time.

However, although data was collected from inservice teachers, no experts participated in this research. In addition, all data was collected from teachers in one school district. If data were collected from teachers in other settings or from content-area or teaching experts, evidence of *foundationalist* beliefs may be found. This is a question for future research.

Finally, the rank-scaled and Likert-type items performed very differently when assessing *teacher epistemic beliefs*. This may have happened for two reasons. First, the addition of science content in the rank-scaled items necessitated that teachers assess their beliefs about both subject-matter and pedagogical knowledge. In addition, different science content areas may lend

themselves to diverse pedagogical practices. As a result, participants rated the items very differently.

Limitations of the Present Study

Although this dissertation study answers very important questions and adds to the personal epistemology literature by attempting to create a valid and reliable measure of *teacher epistemic beliefs* using philosophical definitions, there are some limitations with the study. First, the size of the sample is not large. Although the majority of the preservice teachers who were asked to participate in the study did in fact participate in at least one data collection point, only 17 inservice teachers participated. Thus, more work needs to be completed to determine the epistemic beliefs of inservice teachers. In addition, although the sample of Professional Development School interns and mentor teachers was chosen specifically for their training in the use of evidence and justification, they may not be representative of all teachers. Thus, more work is necessary to determine the beliefs of teachers with more traditional types of training. In addition, teachers' pedagogical practices in science were studied here. In future studies, this will need to be expanded to include an assessment of beliefs in different content areas.

Future Directions for Research

Given these limitations, a number of future studies can be conducted. First, studies involving the collection of data from a larger sample should be conducted. Increasing the sample size is fundamental in a number of ways. First, the collection of data from more participants will allow for stratified sampling, and permit researchers to determine whether or not there is a difference in how teachers respond to items depending upon the grade level they teach. Second, a confirmatory factor analysis could be conducted on the Likert-type items with a larger sample size. Confirmatory factor analyses should be used instead of exploratory procedures because the

items are written in such a way that they align with the three epistemic frameworks. To test these questions, data from at least 300 participants would need to be collected.

In order to collect data from this number of participants, changes would need to be made in the methodology. First, online data collection may not yield the amount of data that is needed. The implementation of surveys as online instruments can be considered useful in some situations because participants have the opportunity to complete the survey at their leisure. In other words, the time constraints imposed on participants by researchers may hinder some potential participants from completing the survey. Thus, the online administration of surveys attempted to alleviate this problem. However, many of the potential participants for this study did not complete the survey online. This may be because they were asked to participate at the end of the school year. Teachers have a lot of work to do to close the school year, and the addition of an online survey may have added a burden for which they did not feel it necessary to find the time. The potential participants in this study who chose not to complete the instrument may have not seen enough benefit for themselves from participating in the research.

In addition, almost all the inservice teachers who participated in the study during the first administration chose not to participate the second time even though the surveys were given to them as paper copies instead of online. This may have happened for two reasons. First, inservice teachers may not have been able to find the time to complete the surveys because they had too many responsibilities at the end of the school year. Second, they did not perceive an incentive for participating when they had previously participated. In the future, an incentive should be given to teachers to participate. This incentive may be given in the form of money or as a donation of supplies for their classrooms. The addition of an incentive for teachers may increase the number of potential participants who choose to complete the survey.

This instrument can also be used to assess changes in preservice interns' epistemic beliefs over time. The goal of teacher education and of Professional Development Schools is to help preservice interns develop into extremely effective teachers. Thus, it can be assumed that these teachers will develop in their epistemic beliefs as they gain more teaching knowledge and experience. In order to test this effectively, preservice teachers could be given this survey multiple times during their undergraduate careers. Beliefs could be assessed at the beginning of their teaching methods courses and at the beginning and end of their student teaching experiences. The epistemic beliefs of teachers could also be assessed after they have their own classrooms. The change in their belief profiles could then be investigated longitudinally. However, the addition of an incentive must be done in order to collect data from participants throughout their careers. If participants do not perceive a benefit from filling out a survey multiple times, they will not do it.

One of the more interesting findings from this dissertation study is that no teachers gave evidence of a *foundationalist* epistemic belief profile. This may be a direct result of the sample of teachers used in this study. Specifically, the teachers were all members of the same school district, where connections between content areas are emphasized. In addition, preservice participants were taught in primarily a *reliabilist* fashion. Thus, the participants may have been predisposed to beliefs that were not *foundationalist* in nature. However, it is unknown as to whether teachers in the larger population may have *foundationalist* beliefs. Increasing the variability of the sample may result in finding teachers with *foundationalist* beliefs.

Increasing the variability of the sample can occur in two ways. First, the preservice and inservice teachers participating in the present study were all members of the same school district and had similar experiences with teaching. Sampling teachers from other school districts may result in different epistemic belief profiles. In addition, the experience of the sample was

truncated. Preservice teachers with little or no teaching experience were a large part of the sample for this study. Although some inservice teachers were included in the sample, they may not be classified as experts. Those individuals who are experts in pedagogical practices and in content domains should also be sampled to increase the variability of beliefs that are sampled. The inclusion of these individuals may lead to the identification of different belief profiles.

Additionally, assessments of teachers' knowledge of science content should be given in future research. It is possible that teachers responded to the rank-scaled items differentially because they were not familiar with the content areas being tested by the items. This difference in familiarity could lead to the participants answering questions in ways that are different from their beliefs simply because they are guessing at how they should answer the questions. In addition, the rank-scaled items are activities that may occur in classrooms. Teachers' responses may be different due to the grade level they teach because students in various grade levels are differentially able to the complete learning tasks assessed in those items rather than because of their beliefs about viable forms of justification. Thus, assessments of science content knowledge and of knowledge of child development should be given to teachers in future studies to determine whether the differences in the results from the rank-scaled items were due to teachers' beliefs or whether they were due to other factors.

Items in different content areas could be written to further assess the beliefs of elementary teachers. It may be that elementary teachers evidence different epistemic beliefs in different content areas. It has been shown that beliefs can vary depending upon the nature of the content about which the beliefs are assessed (e.g., Braten & Stromso, 2005; Paulsen & Wells, 1998). This may also be true of elementary teachers. They may evidence different epistemic beliefs when asked about the well-structured domains of science and mathematics, or about domains that are more ill-structured, such as history. For example, the assessment of beliefs

using the content of mathematics may produce different results simply because of the nature of the domain. In other words, teachers may believe that the structure of mathematics is more hierarchical in nature. They may believe that the domain is structured in such a way that knowledge of advanced content rests upon the mastery of content that is less intricate in nature. This belief would be *foundationalist* in nature. The inclusion of the domain of mathematics may show that teachers have *foundationalist* beliefs. Similarly, the inclusion of domains such as those of history or literature may lead to the identification of different beliefs because of the varied nature of those domains.

Finally, this dissertation study was an important first step in determining whether teachers espouse the same beliefs that they then use in practice. Evidence that teachers are employing the pedagogical practices that they believe are effected was shown through the analysis of the video narratives. The lesson descriptions, on the other hand, did not show the same results. This may be due to the lack of information provided by the teachers in the lesson descriptions. In other words, the descriptions of lessons given were not detailed enough to be able to show evidence of teachers' beliefs. Different types of data should be collected in future studies to provide evidence that teachers are espousing and enacting the same beliefs. Participants in future studies could be asked to turn in lesson plans that they have taught and could be interviewed about those lesson plans to determine whether their practices and beliefs aligned. This collection of lesson plans may be better suited to collecting data from preservice teachers because they develop more detailed lesson plans than inservice teachers. In addition, teachers could be videotaped during a lesson. They then could view the lesson with a researcher and think aloud about the lesson during the viewing. These two types of data collection may produce more detailed descriptions of *teacher epistemic beliefs* than the lesson descriptions used in this dissertation study.

Summary

This dissertation study has been an investigation of *teacher epistemic beliefs*. In this dissertation, a new instrument was created to assess the epistemic beliefs of teachers as they are evidenced in their pedagogical practices. The creation of this instrument is an important contribution to the literature on epistemic beliefs. Much of the research in personal epistemology to date has focused on the beliefs of undergraduate (e.g., Hofer, 2000; Schommer, 1990) or high school students (e.g., Cano, 2005; Conley et al., 2004; Qian & Alvermann, 1995). However, according to Hofer (2001), the beliefs of students are impacted by the beliefs of their teachers. Thus, it is important to investigate the beliefs of teachers. Not only are there very few studies investigating teachers' beliefs, but there are no studies investigating the relation of teachers' epistemic beliefs and their pedagogical practices.

Thus, this study is an important first step in the identification of the epistemic belief profiles of teachers. In this dissertation study, the reliability and convergent validity of a newly created instrument were assessed. The results of this study show that the Likert-type items on the newly created measure are both internally consistent and stable over time. These items were written in such a way that their content accurately reflects the pedagogical practices of the preservice teachers for whom teaching videos were collected. In addition, the rank-scaled items written for and used in this dissertation study utilized a novel method for assessing beliefs about knowledge. More investigations should be completed to assess the reliability and validity of these items.

In future research, the educational levels of the students whom teachers instruct should be taken into account because curriculum may be different at different elementary grade levels. In addition, more data could be collected to study *teacher epistemic beliefs* in greater detail. Despite

the limitations of this research, the content and methodology used in this dissertation study is an important first step into the investigation of *teacher epistemic beliefs*.

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Appendix A. *Informed Consent Document for Preservice and Inservice Participants Who Are Not Providing the Researcher with Videos.*

Implied Informed Consent Form for Social Science Research
The Pennsylvania State University

Title of Project: Framing Teacher Epistemic Beliefs Through Their Reported and Demonstrated Practices

Principal Investigator: Maeghan N. Edwards, 226 CEDAR Building, University Park
814-777-1713 (mne102@psu.edu)
Advisor: Dr. P. Karen Murphy, 229 CEDAR Building, University Park
814-863-2278 (pkm15@psu.edu)

1. **Purpose of the Study:** The purpose of this research is to create and validate a new instrument that measures teacher epistemic beliefs.

2. **Procedures to be followed:** Preservice teachers will be asked to fill out two surveys at three time points. Inservice teachers will be asked to fill out the surveys at two time points. The first survey asks about practices that you may use in your classroom, and the second survey asks about the use of evidence and justification.

3. **Benefits:** The benefits to you include an opportunity to think about your beliefs about good teaching practices. The benefits to society include teachers who have had the opportunity to think about their beliefs about good teaching practices, and possibly use those practices in their teaching.

4. **Duration/Time:** Three research participation sessions will be conducted, each lasting approximately 20 minutes.

5. **Statement of Confidentiality:** Your participation in this research is confidential. Only the person in charge, and his/her assistants, will know your identity. The data will be stored and secured at 213 Chambers Building in a locked file cabinet. In addition, data stored on the computer will be password protected. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared.

6. **Right to Ask Questions:** You can ask questions about this research. Contact Maeghan N. Edwards at (814) 777-1713 with questions. You can also call this number if you have complaints or concerns about this research.

7. **Voluntary Participation:** Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

You must be 18 years of age or older to consent to take part in this research study.

Completion and return of the survey implies that you have read the information in this form and consent to take part in the research. Please keep this form for your records or future reference.

Appendix B. *Informed Consent Form for Preservice Participants Who Are Providing the Researcher With Videos.*

Informed Consent Form for Social Science Research
The Pennsylvania State University

Title of Project: Framing Teacher Epistemic Beliefs Through Their Reported and Demonstrated Practices

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1. **Purpose of the Study:** The purpose of this research is to create and validate a new instrument that measures teacher epistemic beliefs.

2. **Procedures to be followed:** Preservice teachers will be asked to fill out two surveys at three time points. Inservice teachers will be asked to fill out the surveys at two time points. The first survey asks about practices that you may use in your classroom, and the second survey asks about the use of evidence and justification. Preservice teachers will be asked to allow the researcher access to the videos they created during their coursework in the Fall 2006. Videos will be stored in a locked office on a password protected computer and will be destroyed in one year.

3. **Benefits:** The benefits to you include an opportunity to think about your beliefs about good teaching practices. The benefits to society include teachers who have had the opportunity to think about their beliefs about good teaching practices, and possibly use those practices in their teaching.

4. **Duration/Time:** Three research participation sessions will be conducted, each lasting approximately 20 minutes.

5. **Statement of Confidentiality:** Your participation in this research is confidential. Only the person in charge, and his/her assistants, will know your identity. The data will be stored and secured at 213 Chambers Building in a locked file cabinet. In addition, data stored on the computer will be password protected. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared.

6. **Right to Ask Questions:** You can ask questions about this research. Contact Maeghan N. Edwards at (814) 777-1713 with questions. You can also call this number if you have complaints or concerns about this research.

7. **Voluntary Participation:** Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to

take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent form for your records.

_____	_____
Participant Signature	Date
_____	_____
Person Obtaining Consent	Date

Appendix C. *Demographic Information Collected from Preservice Participants.*

DEMOGRAPHIC INFORMATION

1. Name: _____
   (*Note*: Your name will be used only for tracking purposes and will not be given to anyone.)

2. I am a(n)
   a. Undergraduate student.
   b. Certification student.

3. What is the name of the school in which you teach? _____

4. What grade level do you currently teach? _____

5. Please enter the approximate number of students in your class. _____

6. Please enter your approximate GPA. _____

7. What is your favorite subject to teach? _____

8. Please briefly describe your inquiry project below.

Appendix D. *Demographic Information Collected from Inservice Participants.*

DEMOGRAPHIC INFORMATION

1. Name: _____
   (*Note*: Your name will be used only for tracking purposes and will not be given to anyone.)

2. What is the name of the school in which you teach? _____

3. What grade level do you currently teach? _____

4. Please enter the approximate number of students in your class. _____

5. What is your favorite subject to teach? _____

6. What is the highest degree you have attained? _____

Appendix E. *Full Instrument Used in this Dissertation Study.*

Name: _____ Email: _____

EFFECTIVE TEACHER PRACTICES

Directions: Please respond to the following question in writing.

Please describe an effective science lesson you have taught in the past year. What *instructional activities* did you use to teach students the content? How did you *assess* whether students had acquired understandings regarding the content of the lesson? Please provide examples of *cues* or *prompts* you provided to the students when they had difficulty understanding the topic.

Approximate date of lesson: _____

Grade-level of the students: _____

Lesson/Unit Title: ____ _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

TEACHER BELIEFS AND PRACTICES

Part I Directions: Indicate the extent to which *you* feel each of the pedagogical practices below is ***useful*** in your teaching by circling one of the numbers.

1. As a teacher, I emphasize the links between as many concepts as possible.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

2. In my teaching, I help students connect new concepts with other concepts they know.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

3. The examples I use in my teaching are derived from a few basic understandings.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

4. I use demonstrations in my teaching to show how reasoning can be confirmed with data collected as evidence.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

5. When I teach, I ask my students to explain how new information builds upon what is known to be true.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

6. I ask my students to explain how their new understandings can be verified through the collection of data.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

7. The examples I use in my teaching are supported by evidence collected from the natural environment.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

8. I teach my students to describe how their observations are based on facts that are always true.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

9. I teach my students facts that are based on known truths rather than opinion.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

10. As a teacher, I show that explanations based on observable evidence are more viable than explanations not based on observable evidence.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

Part I (continued): Indicate the extent to which *you* feel each of the pedagogical practices below is ***useful*** in your teaching by circling one of the numbers.

11. I teach my students to consider whether new information aligns with what they already understand.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

12. I use demonstrations in my teaching to reinforce students' basic understanding about the content.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

13. As a teacher, I emphasize the importance of aligning thinking with observable evidence.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

14. The content I teach in school is based on a few core concepts.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

15. As a teacher, I provide explanations to show that new information is related to numerous concepts.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

16. I teach my students to explain new facts using facts known to everyone.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

17. I teach my students understandings that are evident to everyone.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

18. I teach my students to describe how to collect observations that inform their understandings.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

19. I teach my students to explain new facts by connecting them with their existing understandings.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

20. I ask my students to explain how their new understanding is consistent with their existing knowledge base.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

Part I (continued): Indicate the extent to which *you* feel each of the pedagogical practices below is ***useful*** in your teaching by circling one of the numbers.

21. I teach my students to justify their understandings with observable evidence.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

22. As a teacher, I provide explanations for new facts that build upon basic understandings.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

23. I teach my students to explain how their conclusions should be checked by using observable evidence.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

24. I teach my students to provide evidence for their thinking.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

25. In my classroom, I encourage students to examine links among concepts.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

26. The content I teach in school shows that many concepts are related.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

27. The content I teach in school requires students to reason based on evidence.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

28. The examples I use in my teaching emphasize the ways in which concepts are related.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

29. As a teacher, I think the premises underlying a topic are central to acquiring knowledge.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

30. I use demonstrations in my teaching to reinforce that no one understanding is more important than any other.

|-----1----------2----------3----------4----------5----------6----------7-----|
not very useful very useful

Part II-A Directions: ***Rank*** the following *instructional activities* based on their ***importance*** in your teaching. Put a **1** beside the activity that is ***most important*** to your teaching. Put a **2** beside the activity that is of ***moderate importance***. Put a **3** beside the activity that is ***least important***. Each rank should be used once for each topic.

1 = *most* in importance	**2 = *moderate* in importance**	**3 = *least* in importance**

Weather Patterns

_____ Have students describe the fundamental concept of convection.

_____ Have students predict the weather for the next two days and test their predictions by observing the weather.

_____ Have students explain the relations between a number of weather phenomena, such as evaporation, condensation, and precipitation.

Magnets

_____ Have students read a text on the roles of size, density, and increasing polarity on the strength of magnets.

_____ Have students explain why polarity is the basic property of magnets.

_____ Have students reason and test objects in the classroom for their ability to take on the properties of magnets.

Plants

_____ Have students collect data and draw conclusions regarding the effect of varied amounts of light on plant growth.

_____ Have students explore the relations between plant growth, survival, and reproduction.

_____ Have students break into groups and discuss the fundamental role photosynthesis plays in plant life.

Light

_____ Have students describe the relations between light absorption, reflection of light, and shadow formation.

_____ Have students speculate about what colors will be reflected when light hits different objects and test those predictions.

_____ Have students describe the core concept that light travels in a straight line.

Part II-B Directions: ***Rank*** the following *assessment activities* based on their ***importance*** in your teaching. Put a **1** beside the activity that is ***most important*** to your teaching. Put a **2** beside the activity that is of ***moderate importance***. Put a **3** beside the activity that is ***least important***. Each rank should be used once for each topic.

1 = *most* in importance	**2 = *moderate* in importance**	**3 = *least* in importance**

Weather Patterns

_____ Ask students to explain the central role of convection in understanding weather patterns.

_____ Ask the students to explain how changes in precipitation, wind speed, temperature, and cloud cover all interact with each other.

_____ Ask students to forecast the weather from data you have given them in a table.

Magnets

_____ Ask students to think about which objects are magnetic and support their choices with evidence.

_____ Ask students to determine the central property shared by ball, bar, and horseshoe magnets.

_____ Ask students to describe the factors that influence how a compass works.

Plants

_____ Ask students to design their own plant and illustrate the components necessary for its survival in a particular habitat.

_____ Ask students to speculate and provide supporting evidence about how a gradual warming of the environment will affect the survival of plants.

_____ Ask students to write a story about what would happen to plants if there were no sun.

Light

_____ Ask students to test their hypothesis about what can make a wall appear a different color than its original color.

_____ Ask students to pretend they are a beam of light and describe their journey from a source to an object.

_____ Ask students to explain how light travels from a light bulb to allow them to see the words on a piece of paper with their eyes.

Part II-C Directions: ***Rank*** the following *cues or prompts* based on their ***importance*** in your teaching. Put a **1** beside the activity that is ***most important*** to your teaching. Put a **2** beside the activity that is of ***moderate importance***. Put a **3** beside the activity that is ***least important***. Each rank should be used once for each topic.

1 = *most* in importance	**2 = *moderate* in importance**	**3 = *least* in importance**

Weather Patterns

_____ "Remember to think about how wind chill relates back to what you already know about temperature change."

_____ "It may be helpful for you to draw a chart showing how wind speed, temperature, and cloud cover are related."

_____ "What do you think would happen to temperature and precipitation if you changed the wind direction? Be sure to provide evidence."

Magnets

_____ "What do you already know to be true about magnets?"

_____ "Tell me whether or not your results support your hypothesis that magnets always stick to other magnets."

_____ "Describe some characteristics of magnets. Does the chalkboard eraser have that characteristic?"

Plants

_____ "Remember, it's important that your hypothesis be supported by the data you collected when we grew the bean plants."

_____ "Be sure to consider the connections between a plant's shelter, water, and survival."

_____ "How does your answer relate back to what you already know about plant growth?"

Light

_____ "It might help to review the connections among the properties of light with your classmate."

_____ "Be sure to consider the most basic property of light."

_____ "Think back to the experiments we have conducted in class. How are the results for your new experiment similar or different?"

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PUBLICATIONS

Murphy, P. K., Buehl, M. M., Zeruth, J. A., Edwards, M. N., Monoi, S., & Long, J. F. (in press). Examining the influence of epistemic belief and goal orientations on the academic performance of adolescent students enrolled in high-poverty, high-minority schools. In L. D. Bendixen & F. C. Haerle (Eds.), *Personal epistemology in the classroom: Theory, research and implications for practice*. Cambridge: Cambridge University Press.

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Edwards, M. N., Higley, K. H., Zeruth, J. A., & Murphy, P. K. (2007). Pedagogical practices: Examining preservice teachers' perceptions of their abilities. *Instructional Science, 35*, 443-465.

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Murphy, P. K., Alexander, P. A., Greene, J. A., Edwards, M. N. (2007). Epistemological threads in the fabric of conceptual change. In S. Vosniadou, A. Baltas, & X. Vamvakoussi (Eds.), *Re-framing the conceptual change approach in learning and instruction*. Dordrech, Netherlands: Elsevier.

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SELECTED PRESENTATIONS

Edwards, M. N. (2006, August). *The Pennsylvania System of School Assessment 11th grade mathematics exam: Which standards contribute to proficiency level?* Paper presented at the annual meeting of the American Psychological Association, New Orleans, LA.

Higley, K., & Edwards, M. N. (2006, August). *A new paradigm for mathematics education: Persuasive pedagogy in action*. Paper presented at the annual meeting of the American Psychological Association, New Orleans, LA.

Edwards, M. N., Higley, K. J., Wright, M., Kulikowich, J. M., & Van Meter, P. (2005, August). Intervening to facilitate emergent expertise: Multiple methodologies. In M. N. Edwards (Chair), *The road to domain expertise: Texts, situations, technology, and methodology*. Symposium presented at the annual meeting of the American Psychological Association, Washington, DC.

Higley, K. J., Edwards, M. N., & Gushka, J. A. (2005, August). The viability of the persuasion metaphor for educators with varying levels of teacher-efficacy. In H. Fives (Chair), *Teaching as persuasion: Is the metaphor viable?* Symposium presented at the annual meeting of the American Psychological Association, Washington, DC.

Murphy, P. K., Alexander, P. A., Greene, J. A., & Edwards, M. N. (2005, April). Epistemological threads in the fabric of conceptual change. In P. K. Murphy (Chair), *Examining the hinge: The influence of epistemological beliefs in conceptual change*. Symposium presented at the annual meeting of the American Educational Research Association, Montreal, Canada.

Murphy, P. K., & Edwards, M. N. (2005, April). What the studies tell us: A meta-analysis of discussion approaches. In I. Wilkinson (Chair), *Making sense of group discussions designed to promote high-level comprehension of texts*. Symposium presented at the annual meeting of the American Educational Research Association, Montreal, Canada.