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Dimensionality and Disciplinary Differences in Personal Epistemology

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A growing body of work addresses the nature of epistemological development and epistemological beliefs: how individuals come to know, the theories and beliefs they hold about knowing, and the manner in which such epistemological premises are a part of and an influence on the cognitive processes of thinking and reasoning. This study investigates the dimensionality of personal epistemology as hypothesized in a recent review of the literature as well as the nature of disciplinary differences. First-year college students responded to a set of questionnaires that included an adaptation of a domain-general epistemological instrument and a discipline-focused questionnaire. Results suggest that there is an underlying dimensionality to epistemological theories that cuts across disciplinary domains, but that students, at least by the 1st year of college, discriminate as to how these theories differ by discipline. Disciplinary differences were strong, suggesting that 1st-year college students see knowledge in science as more certain and unchanging than in psychology, are more likely to regard personal knowledge and firsthand experience as a basis for justification of knowing in psychology than in science, view authority and expertise as the source of knowledge more in science than in psychology, and perceive that in science, more than in psychology, truth is attainable by experts. This contradicts existing research that suggests that epistemological development is domain general and that epistemological beliefs do not differ by discipline.

How individuals come to know, the theories and beliefs they hold about knowing, and the manner in which such epistemological premises are a part of the cognitive processes of thinking and reasoning have been addressed in several simultaneous and intersecting lines of research (Baxter Magolda, 1992; Belenky, Clinchy, Goldberger, & Tarule, 1986; King & Kitchener, 1994; Perry, 1970; Schommer, 1990). Much of this work suggests a developmental stage model, in which beliefs about knowledge and knowing are integrated hierarchically and cut across disciplines and domains. These are com-

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posed of dimensions that vary only slightly from model to model. Most recently, this has been defined as a system of more or less independent ''epistemological beliefs'' (Schommer, 1990; Schommer, Crouse, & Rhodes, 1992), which can influence comprehension and learning. It is suggested that these beliefs are organized into five hypothesized dimensions (Schommer, 1994). It has also been proposed that the various beliefs and assumptions one holds about knowledge and knowing form epistemological theories, made up of multiple dimensions (Hofer & Pintrich, 1997), four of which appear with some consistency across the extant literature.

Individual conceptions of epistemology are an important area for research and may provide further insight into how individuals make meaning and how this in turn affects learning. Epistemological beliefs have been shown to influence comprehension, study strategies, and academic performance (Garrett-Ingram, 1997; Schommer, 1990, 1993b; Schommer, Crouse, & Rhodes, 1992). Clearer understanding of the construct, the number and type of dimensions, and the nature of domain specificity or generality are necessary in order to better understand the relation between personal epistemology and student learning as well as the instructional implications of these relations.

Although some work has been done to address the relationships among particular models (Bendixen, Dunkel, & Schraw, 1994; Brabeck, Simi, & King 1996), little work exists that tests the dimensions suggested as common to various models. Such work is needed for further clarification of the construct and as a basis for further empirical studies. Furthermore, the underlying assumption that epistemological theories and beliefs are domain general may be an artifact of both the developmental model inherent to most of the research conducted as well as an outcome of assessment instruments that were explicitly designed to tap more general beliefs. This study addresses both the nature of the dimensions of personal epistemology as identified across models (see Hofer & Pintrich, 1997) and the issue of disciplinary differences in epistemological theories.

PERSONAL EPISTEMOLOGY: CONSTRUCT AND DIMENSIONS

Nearly all the existing psychological work on epistemological beliefs and theories can be traced to two longitudinal studies by Perry (1970), who provided a general heuristic for understanding how college students make meaning of their educational experiences and how this is transformed over time. The trajectory he described indicates that students move from a dualistic conception of knowledge (knowledge is black and white, right and wrong) to a multiplistic stance (one opinion is as good as another) and then to relativism (an understanding that knowledge is contingent and contextual). The final stage in the scheme, rarely exhibited among college students, is that of commitment within relativism, marked by choice and affirmation of one's position.

Following Perry's lead, most researchers in the field have posited models that are to some degree structural, developmental sequences. One group has been largely interested in how individuals interpret their educational experiences (Baxter Magolda, 1987, 1992; Belenky et al., 1986; Perry, 1970, 1981). Perry's pioneering endeavors were with a sample that was almost entirely male; in response, Belenky et al. (1986) investigated ''women's ways of knowing'' with an exclusively female sample. Baxter Magolda (1992), intrigued by gender implications of these two lines of research, chose to investigate similar concerns with both men and women in her model of ''epistemological reflection.''

A second group of researchers have been interested in how epistemological assumptions influence thinking and reasoning processes, focusing on reflective judgment (King & Kitchener, 1994; Kitchener & King, 1981; Kitchener, King, Wood, & Davison, 1989; Kitchener, Lynch, Fischer, & Wood, 1993) and skills of argumentation (Kuhn, 1991, 1993). The third and most recent line of work has taken the approach that epistemological conceptions are a system of beliefs that may be more or less independent rather than reflective of a coherent developmental structure (Schommer, 1990, 1994). These beliefs appear to influence comprehension and cognition for academic tasks and thus have implications for classroom academic performance.

Although there are distinctions among the models, there are points of convergence among them about what individuals believe knowledge is and how it is they know. It seems increasingly clear that personal epistemological theories, as described throughout the existing literature, are made up of somewhat discrete, but perhaps interrelated, dimensions. These elements that comprise personal epistemological theories appear explicitly in some developmental models (Baxter Magolda, 1992; King & Kitchener, 1994) and must be inferred in others (Kuhn, 1991; Perry, 1970). When those dimensions that relate solely to educational experience or to learning rather than knowing are eliminated (see Hofer & Pintrich, 1997), the dimensions of personal epistemology seem to cluster into two areas: the *nature of knowledge* (what one believes knowledge is) and the *nature or process of knowing* (how one comes to know). Within these, there appear to be two dimensions each. Under nature of knowledge, there are the dimensions *certainty of knowledge* and *simplicity of knowledge*, and within the area of nature of knowing, two other dimensions, *source of knowledge* and *justification of knowledge*. A brief description of each of these four dimensions follows.

Certainty of Knowledge

The degree to which one sees knowledge as fixed or more fluid appears throughout the research, with developmentalists likely to see this as a continuum that changes over time, moving from a fixed to a more fluid view. At lower levels, absolute truth exists with certainty. At higher levels, knowledge

is tentative and evolving. Openness to new interpretation is a key element of King and Kitchener's (1994) highest stage of reflective judgment, and Kuhn (1991) speaks of evaluative epistemologists (the highest level) as open to the possibility that their theories may be modified by genuine interchange.

Simplicity of Knowledge

As conceptualized by Schommer (1990, 1994), knowledge is viewed on a continuum as an accumulation of facts or as highly interrelated concepts. Similarly, within other schemes, the lower level view of knowledge is seen as discrete, concrete, knowable facts; at higher levels individuals see knowledge as relative, contingent, and contextual.

Source of Knowledge

At lower levels of most of the models, knowledge originates outside the self and resides in external authority, from whom it may be transmitted. The evolving conception of self as knower, with the ability to construct knowledge in interaction with others, is a developmental turning point of most models reviewed. Perry (1970) described this awareness as one of the shifts in his model, when ''the person, previously a holder of meaning, becomes a maker of meaning'' (p. 87). Similarly, King and Kitchener (1994) describe a shift in the action of knowing in the higher stages, with the knower moving from spectator to an active constructor of meaning. Belenky et al. (1986) provided the most extensive elaboration on the issue of source of knowledge, which became the focal point in their study of how women come to know. Baxter Magolda (1992) describes an evolution in knowing that focuses on shifts in the role of learner, the role of peers, and the role of instructor. Schommer has postulated source of knowledge as a fifth dimension in her theory of epistemological beliefs (Schommer, 1990, 1994), focusing primarily on beliefs about authority, although its existence has not been demonstrated empirically.

Justification for Knowing

This dimension includes how individuals evaluate knowledge claims, including the use of evidence; the use they make of authority and expertise; and their evaluation of experts. In the reflective judgment model (King & Kitchener, 1994), individuals at lower levels justify beliefs through observation or authority, or on the basis of what feels right, when knowledge is uncertain. Only at higher stages do individuals use rules of inquiry and begin to personally evaluate and integrate the views of experts.

It is hypothesized that these four dimensions should be considered the core of an individual's epistemological theory, while the other beliefs about learning, teaching, and intelligence may be related to the core dimensions, but are peripheral to an individual's conception of epistemology, analogous

to the distinction between core and peripheral ideas in the conceptual change literature (Pintrich, Marx, & Boyle, 1993). Considering the four dimensions to be aspects of an individual's personal theory of epistemology does suggest that the dimensions are related to each other in coherent and internally consistent ways, make some important distinctions about knowledge, and may provide a causal-explanatory framework for thinking about knowledge. Only with better identification of these dimensions can we proceed to establish the relations among them and their impact on other cognitive processes. One goal of this study is to empirically test the existence and representation of these four dimensions: certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowing.

DOMAIN GENERALITY/SPECIFICITY IN PERSONAL EPISTEMOLOGICAL THEORIES

Most work on personal epistemology has presumed that the beliefs and theories individuals hold about knowledge and knowing are general and that they transcend domains. Early work in this area was influenced by Piagetian developmental theory, with underlying assumptions of domain generality, although these were seldom tested. The Piagetian explanation for differences across domains has been that of horizontal decalage, a lag in operations or processes across tasks or domains. Accordingly, the issue of domain specificity has had only marginal attention within the research on epistemological development. Disciplinary differences were found in only one study of reflective judgment cited by King and Kitchener (1994), in which social science graduate students were higher in epistemic reasoning than those in mathematical sciences, even with GRE scores partialed out.

Two studies indicate that epistemological beliefs vary as a function of field of study. Students studying in social science and humanities were more likely than students in engineering and business to view knowledge as uncertain (Jehng, Johnson, & Anderson, 1993). Similarly, using a typology of academic disciplines as hard-soft and pure-applied, Paulsen and Wells (1998) found that students in applied fields held more naive beliefs about the structure and certainty of knowledge and the speed of learning than did those in pure fields and that students in fields considered both applied and hard, such as engineering, saw knowledge as more certain than those in fields considered both pure and soft, such as the social sciences. While such evidence suggests differing educational outcomes as a result of differing emphases in disciplinary training, it does not reveal whether individual students hold differing epistemological theories *about* different domains. These particular studies were both between-subject designs; within-subject designs are needed to assess whether individual beliefs differ about particular domains.

Current measures of personal epistemology are designed specifically to assess general beliefs about knowledge and knowing; thus most existing in-

terview questions and questionnaire items are written in ways that suggest domain generality. Discipline-based problems for business and psychology were developed by King and Kitchener (1994) and they note that average scores on the discipline-based problems in several pilot studies are almost identical to those scores on the standard problems. Although this was a within-subject design, the focus of the study appears to be on comparing scores on a discipline-based problem to scores on standard problems rather than comparing scores on different disciplinary issues. They conclude that their instrument taps general underlying assumptions about knowledge and not assumptions particular to a discipline. Thus we may not have an existing measure effective for the assessment of disciplinary differences in beliefs and theories.

This issue of instrument sensitivity is important in making claims about whether individuals perceive differences in the epistemology of different disciplines. Schommer and Walker (1995) assert that epistemological beliefs are moderately similar across social science and mathematics and conclude that individuals' epistemological beliefs tend to be domain independent (Schommer & Walker, 1995). This study included one experiment in which there were two groups of students, each completing instruments in only one domain, and one experiment with a within-subject design. However, as the authors note, the instrument used in that study was specifically designed to measure more general beliefs; typical items include ''I don't like movies that don't have an ending'' and ''The only thing that is uncertain is uncertainty itself.'' Although the participants were directed to keep a particular domain in mind, and the questionnaire was revised to include reference to the domain approximately every third item, the questionnaire still has a number of items that refer to general knowledge beliefs. The alterations may not be adequate to affect participants' responses or provide evidence of beliefs pertinent to a discipline.

Furthermore, increasing work on the nature of knowledge and knowing within different disciplines suggests that epistemological differences do exist, are a part of the defining nature of the disciplines, and that these differences increase as expertise develops (Donald, 1990; Langer, 1994; Roth & Roychoudhury, 1994; Schoenfeld, 1992; Stodolsky, Salk, & Glaessner, 1991). A growing body of literature addresses beliefs about knowledge within particular disciplines, particularly in the math and science areas (Buerk, 1985; Carey & Smith, 1993; Donald, 1986, 1990; Lampert, 1990; Roth & Roychoudhury, 1994; Schoenfeld, 1983, 1988; Stodolsky et al., 1991). For example, many students believe that mathematics is associated with certainty and getting the right answer quickly and that the teacher is the arbiter or source of knowledge (Lampert, 1990). Typical student beliefs about mathematics as identified by Schoenfeld (1992) include the belief that math problems have one and only one right answer and that there is only

one way to solve any math problem. Within a broader study of attitudes and beliefs about learning math and social studies, Stodolsky, Salk, and Glaessner (1991) have tapped naive views of disciplinary differences among fifth graders: math appeared more fixed and immutable and social studies less sharply defined. Studies of epistemological beliefs in the sciences include research on college students' beliefs about the structure, content, and learning processes of physics (Hammer, 1994); the constructivist or objectivist ''epistemological commitment'' of high school physics students (Roth & Roychoudhury, 1994); and what Carey and Smith (1993) tag the ''common sense'' epistemology of seventh-grade students with objectivist or realist beliefs about the certainty of science.

Research on domain differences is complicated by the fact that academic disciplines do have differing knowledge structures and epistemological assumptions (Donald, 1995; Schwab, 1964, 1978), which is seldom considered in the more general literature on epistemological beliefs and development. Defining characteristics of the disciplines include the criteria and validation processes used to determine knowledge (Donald, 1986). For example, faculty members in English language and literature rely more on peer judgment and less on empirical evidence than those in either natural or social sciences (Donald, 1990). Discipline-specific ways of knowing and reasoning have been found among the teaching practices and goals of high school teachers (Langer, 1994). Donald (1990) suggests further study of the determining characteristics of the disciplines and how these might intersect with instruction and student learning.

It seems quite plausible that individuals hold a set of general epistemological beliefs yet are likely to make distinctions about the application of these beliefs to particularly well-defined disciplinary areas. Such distinctions may become more developed over time with more focused disciplinary training. What we need to know is (a) to what extent the dimensions of epistemological beliefs are consistent from discipline to discipline, as evidenced in similarity of factor structures; (b) what differences there might be in the beliefs about disciplines, as suggested by mean differences in beliefs; and (c) how these relate to more general epistemological beliefs, as suggested by intercorrelations among domain-specific and domain-general beliefs. All three of these issues are examined in this study.

MEASUREMENT ISSUES IN THE STUDY OF PERSONAL EPISTEMOLOGY

The study of personal epistemology has been conducted through interviews, production tasks, and a variety of written instruments. Although interviews may provide a better window on individual beliefs and allow the researcher better access to the meaning-making process, this is a time-

consuming and costly process and thus typically restricts the researcher to a relatively small sample. There are several written questionnaires that tap certain aspects of personal epistemology as initially outlined by Perry (1970), such as the Measure of Epistemological Reflection, a set of essay stems related to classroom learning (Baxter Magolda, 1992); the Measure of Intellectual Development (MID), a production-task instrument with essay stems; and the Learning Environment Preferences (LEP), a recognition-task instrument with forced-choice items (see Moore, 1991, for more information on the MID and LEP). Assessment of reflective judgment (King & Kitchener, 1994) has been limited to interviews that must be scored by trained raters, although a written version of the Reflective Judgment Interview is currently under development. A more general assessment of epistemological beliefs is available through Schommer's Epistemological Belief Questionnaire (Schommer, 1990), a self-report questionnaire with items rated on a Likert-type scale. Although the other written instruments have been widely used by educators for diagnostic and evaluation purposes, this questionnaire has had the widest use among researchers, particularly in correlational studies of epistemological beliefs and student learning. Limitations include very broadly stated items, the reference of items to both individual and others' perceptions, and the absence of confirmatory factor analysis on the items rather than subscales (Hofer & Pintrich, 1997).

While each of these instruments has value in particular, none tap all of the dimensions of epistemological beliefs suggested throughout the literature. Nor do they provide appropriate means for assessing disciplinary differences of beliefs across these dimensions. Although each of the existing instruments has contributed to the development of the field, continued work is needed in instrument development. One central purpose of this study was to design a measure that not only tapped the multiple dimensions described in the literature, but that could also be used to discern disciplinary differences in beliefs. This measure was administered along with a version of the Schommer Epistemological Belief Questionnaire, which appeared to be the most useful paper-and-pencil measure of general epistemological beliefs for large-scale administration and which has been demonstrated to tap at least two of the dimensions of interest in this study, certainty of knowledge and simplicity of knowledge. Use of the existing instrument provides some evidence for the validity of the new instrument, as it is designed to tap similar dimensions.

RESEARCH QUESTIONS

This study has two primary purposes: (1) to assess the dimensions of personal epistemology as suggested across models, through the development of a new instrument; and (2) to examine whether individuals distinguish disciplinary differences in epistemological beliefs. The new instrument tested in

this study was designed to address two central components of personal epistemological theories, the nature of knowledge and the process of knowing, and to tap specific dimensions within these as suggested throughout existing research: certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowing. It was hypothesized that these four dimensions would be identified with the new instrument. The second hypothesis central to this study was that there would be evidence for disciplinary differences in epistemological theories.

Besides the main research questions, several other questions were explored. Additional research questions concern the extent to which choice of academic major relates to discipline-specific epistemological beliefs, an exploration of gender differences and epistemological beliefs as assessed by the new instrument, and the relation between grades and both general and discipline-specific epistemological beliefs.

In earlier studies (Jehng, Johnson, & Anderson, 1993; Paulsen & Wells, 1998), academic major was found to be related to general epistemological beliefs. These studies compared beliefs, as measured by versions of the Schommer questionnaire, of students in ''soft'' and ''hard'' fields. Results from Jehng, Johnson, and Anderson (1993) suggested that students in the social sciences, arts, and humanities were more likely to see knowledge as uncertain, to view learning as dependent upon independent reasoning, and to see learning as a less orderly process than those in engineering and business. However, there appears to be no research examining the relation of major and discipline-focused beliefs. Given the fact that students in this study have only recently begun college and thus academic work in their chosen area of study is not well advanced, it is hypothesized that choice of major is not yet a significant correlate of epistemological beliefs.

The role of gender and personal epistemology has been explored in multiple lines of work (Baxter Magolda, 1992; Belenky et al., 1986; King & Kitchener, 1994) but with inconclusive evidence. Given that Perry's (1970) research had been almost entirely with men, Belenky et al. (1986) chose to use an all-female sample for their research and then identified an epistemology they labeled ''women's ways of knowing.'' Their work has often been cited as evidence that women are more likely to favor a ''connected'' approach to knowing and that the typical academic environment privileges the more ''separate'' mode of knowing favored by men. This is a considerable extension of the original work, which, as noted, included only female subjects, and the work has yet to be replicated with a mixed-gender sample. Baxter Magolda (1992) selected both men and women for a longitudinal study of college students; this work suggests that the sequence of what is called ''epistemological reflection'' is similar for men and women, but that there are gender-related patterns in their ways of knowing. King and Kitchener (1994) found gender differences only in the later testings in their 10-

year study, which they speculate as attributable to greater educational attainment by the men; they report that of 14 other studies utilizing the Reflective Judgment Interview, half reported no gender differences, but 6 of the other 7 reported higher scores among males. Although the issue of gender and personal epistemology needs more deliberate investigation than this current study permits, it is important to include this as a research question, given the nature of previous findings. Given the age of the subjects in this study and their common educational attainment, it is hypothesized that there would be no significant gender differences in the findings.

Finally, epistemological beliefs have been found to be a predictor of academic performance (Schommer, 1993b), with more sophisticated beliefs predicting overall grade point average (GPA). Previous work, however, has not identified the relation between beliefs about disciplines and grades in both related courses and overall grade point average. It is predicted that disciplinary beliefs would be correlated with academic performance in the related subject areas as well as with overall performance.

METHOD

Participants

A total of 326 1st-year college students participated in the study; 53% of the participants were female. Students were enrolled in an introductory psychology course and participated as part of course requirements. The purpose of their participation was to learn more about psychological research; accordingly, they were provided both written materials and an oral debriefing at the conclusion of the study. These included information about the purposes of the research as well as research design and methodology.

Materials

Each participant was given a packet of instruments that included a shortened version of the Schommer general epistemological beliefs questionnaire and two forms of a newly developed epistemological beliefs instrument, identical except that one was headed ''Psychology'' and one ''Science.''[1]

General epistemological beliefs questionnaire. A shorter, revised version of the Schommer Epistemological Belief Questionnaire developed by Qian and Alvermann (1995) was selected for use. In its original form, the Schommer questionnaire is a 63-item questionnaire that has generally yielded four factors when 12 subsets of items are used in the factor analysis (Schommer, 1993a). In this study, in order to test the dimensional properties of multiple instruments, it was desirable to use a version of the questionnaire with potential for factoring of items rather than predetermined scales. This shortened version of the Schommer questionnaire was developed by Qian and Alvermann (1995), who first eliminated items hypothetically related to a fifth factor that had not surfaced in earlier research and then further eliminated those that had factor loadings of less than .30 when an item-based factor analysis was conducted. Their factor analysis of the items, rather than the factor analysis of subscales used by Schommer (1993a), yielded three factors, with certainty and simplicity merging as one factor. This ques-

[1] These headings were used because all students were enrolled in introductory psychology but had diverse experience in natural science courses.

tionnaire, used in this study as a measure of domain-general beliefs, is referred to as the General Epistemological Beliefs Questionnaire. It contains 32 items rated on a 5-point scale (1 = *strongly disagree;* 5 = *strongly agree*). Sample items include ''Today's facts may be tomorrow's fiction,'' ''The only thing uncertain is uncertainty itself,'' and ''Most words have one clear meaning.''

Discipline-focused epistemological beliefs questionnaire. The discipline-focused questionnaire contains items that were adapted from existing instruments (Perry's Checklist of Educational Values and Schommer's epistemological beliefs questionnaire) and additional items that were written in accordance with the four proposed dimensions of epistemological theories (Hofer & Pintrich, 1997) as extrapolated from work by Perry (1970), King and Kitchener (1994), Kuhn (1991), Baxter Magolda (1992), and Belenky et al. (1986). The questionnaire was developed by a team of researchers familiar with the literature and reviewed by three psychologists for wording, content validity, and relevance to each of the four dimensions. Attempts were made to develop items that represented the dimensionality of personal epistemology as suggested in a review of the literature (Hofer & Pintrich, 1997), to focus the items on domain-specific knowledge, and to write these items at a level that would be understandable to college students.

In this questionnaire each item typically refers to the field or subject matter as the frame of reference; for example, ''In this field, knowledge is certain.'' With this instrument, students were asked to keep a particular discipline in mind, either psychology or science, when responding, rating each of the 27 items on a 5-point scale (1 = *strongly disagree;* 5 = *strongly agree*).

Performance Measures

Grades were obtained from the registrar's office for all classes during the term that students participated. Final course grade for an introductory psychology class was used as a measure of academic achievement in psychology, and grade point average (GPA) for the term was used as measure of overall academic performance. Both of these measures were available for almost all participants, with the exception of those who were enrolled pass/fail or who were enrolled in a special program that does not record letter grades. Nearly half ($N = 147$) of the participants were also enrolled in a science class, with the vast majority in an introductory chemistry course. The letter grade for the science course was used as an indicator of performance in science. In the few cases where students were enrolled in more than one science course, the grade for the chemistry course was selected as the science grade, since this was the course in which most students were enrolled.

Procedure

The packets were arranged with the general epistemological beliefs questionnaire first, then one of the discipline-focused questionnaires, followed by a vignette from that discipline and questions eliciting open-ended responses; next was the other discipline-focused questionnaire and then the vignette from that discipline. (Scoring of the vignettes is not included in this study.) The ordering was counterbalanced so that half the students received the science-focused questionnaires first and half received the psychology-focused questionnaires first. Participants were usually scheduled in groups limited to about 20–25 in sessions conducted in seminar-style rooms in order to enhance cooperation and serious attention to the task. Instructions were read aloud for each instrument, with students expected to wait to begin each instrument at the same time as others in the group. In one larger group administration, students were given the packet of materials individually. Each session lasted approximately 50 min. At the end of each session, students were given both written and oral feedback about the objectives and

design of the study and more information about the role of epistemological beliefs in college learning.

RESULTS

Dimensions of Personal Epistemology

In order to examine the initial research question regarding the dimensionality of epistemological theories as evidenced in the discipline-based instrument, exploratory factor analyses were conducted. Initial analyses of the two questionnaires, using an eigenvalue of greater than 1.00, yielded nine factors for psychology and eight for science. However, examination of the scree plots suggested a four-factor model for each. (A natural break fell between the fourth and fifth items in both cases and eigenvalues supported this juncture as the point where values dropped precipitously, clustering near 1.00, with little variation among them.) Items that loaded onto these factors were retained and, based on both these initial analyses and the theoretical development of the instrument, a four-factor solution was forced, with a principal components procedure and varimax rotation. This was then repeated with a maximum likelihood procedure with similar results.[2] Four factors with high loadings (all above .40, except for one item that loaded .32) and eigenvalues greater than 1.00, and all with relevance to the theoretical model, were identified as underlying the discipline-specific questionnaire, regardless of whether the discipline was science or psychology (see Table 1). These factors represent the following dimensions: (1) certain/simple knowledge (eight items, with α equal to .74 in psychology and .81 in science); (2) justification for knowing: personal (four items, with α equal to .56 in psychology and .61 in science); (3) source of knowledge: authority (four items, with α equal to .51 in psychology and .64 in science); and (4) attainability of truth (two items, with α of .60 in psychology and .75 in science). To a limited degree, as described below, these four factors fit the model that had been conceptually developed from a review of the literature, although not all aspects of each dimension are fully represented, and there was some complexity among the items, as indicated on Table 1; items that loaded above .30 on other factors are noted accordingly.

In this factoring of the discipline-based instrument, certainty of knowledge and simplicity of knowledge did not emerge as separate factors, as suggested by the literature. Items that had been hypothesized for both dimensions loaded on one factor, labeled certain/simple knowledge. This finding is similar to the results reported by Qian and Alvermann (1995) in their use of the domain-general epistemological beliefs questionnaire.

[2] There was one minor difference: with the maximum likelihood procedure, the item ''Correct answers in this field are more a matter of opinion than fact'' still showed a complex loading on two factors, but loaded slightly higher on the factor ''source.''

TABLE 1
Factor Analysis of Discipline-Focused Epistemological Beliefs Questionnaire

Variables	Factor loadings							
	Certainty		Justification: personal		Source: authority		Attainment of truth	
	Psy.	Sci.	Psy.	Sci.	Psy.	Sci.	Psy.	Sci.
Answers to questions in this field change as experts gather more information. (R)	.66	.72						
All experts in this field understand the field in the same way.	.64	.62						(.37)
Truth is unchanging in this subject.	.64	.68						
In this subject, most work has only one right answer.	.58	.44				(.46)		
Principles in this field are unchanging.	.62	.71						
All professors in this field would probably come up with the same answers to questions in this field.	.53	.55	(.32)			(.49)		
In this subject, it is good to question the ideas presented. (R)	.50	.51						
Most of what is true in this subject is already known.	.47	.49						(.33)
First-hand experience is the best way of knowing something in this field.			.75	.78				
I am more likely to accept the ideas of someone with firsthand experience than the ideas of researchers in this field.			.73	.79				
Correct answers in this field are more a matter of opinion than fact.			.53	.45		(.32)		
There is really no way to determine whether someone has the right answer in this field.			.48	.50			(.32)	(.32)
Sometimes you just have to accept answers from the experts in this field, even if you don't understand them.					.68	.65		
If you read something in a textbook for this subject, you can be sure it's true.	.32	.48			.60	.46		
If my personal experience conflicts with ideas in the textbook, the book is probably right.			(.38)		.60	.64		
I am most confident that I know something when I know what the experts think.					.53	.70		
Experts in this field can ultimately get to the truth.							.82	.84
If scholars try hard enough, they can find the answers to almost anything.							.76	.82

Note. Numbers in parentheses indicate multiple loadings above .30.

TABLE 2
Factor Analysis of Discipline-Focused Epistemological Beliefs Questionnaire

	Psychology		Science	
Factors	Eigenvalue	% variance explained	Eigenvalue	% variance explained
1. Certainty/simplicity	3.00	16.65	3.24	18.00
2. Justification: personal	1.93	10.73	1.86	10.53
3. Source: authority	1.80	10.01	2.43	13.51
4. Attainment of truth	1.57	8.70	2.00	11.10

Among the other dimensions hypothesized, factors emerged that represented distinct aspects of both justification for knowing and source of knowledge (see Table 2). However, neither represent the breadth of the dimensions as hypothesized; thus they have been named accordingly. ''Justification for knowing: personal'' represents the view that knowing is justified by individual opinion or firsthand experience. This factor does not contain items related to evaluation of evidence, reason, or assessment of expert opinion, which would also be considered aspects of justification for knowing among existing models; these items did not factor in any meaningful way. ''Source of knowledge: authority'' relates specifically to expert knowledge, texts, and other external authority as the source of knowledge. However, this factor did not contain those items related to individual construction of meaning, identified by most theorists as an aspect of the source of knowledge, but which did not factor in a meaningful way in this study. Furthermore, an additional scale emerged regarding the perceived attainability of truth.

Overall, these factor analyses provide some evidence for substantive validity of the suggested dimensions. According to Tabachnick and Fidell (1989), it is unnecessary to proceed to statistical comparison of a pair of factors if similarities between them are sufficiently clear. Because the four-factor structure showed that individual variables loaded highly on the different factors for the two groups (science and psychology) and it was reasonable to use the same labels to name the factors for both groups, the criteria outlined by Tabachnick and Fidell (1989) were met and the need for further statistical analyses was obviated.

In order to obtain evidence for concurrent validity of these dimensions as evidenced in the discipline-specific instrument, an instrument which measure similar constructs was utilized. Two of the dimensions in the general epistemological beliefs questionnaire were of particular relevance in this study as theoretically parallel to the proposed dimensions in the new discipline-specific instrument; these are ''certain knowledge'' and ''simple knowledge.'' However, factor analyses of the 32-item general epistemological be-

TABLE 3
Scales, Items, and Reliabilities for General Epistemological Beliefs

Scale and items	α
Certainty/simplicity of knowledge (11 items)[a]	.66
You will get confused if you try to relate new ideas in a textbook with knowledge you already have about a topic.	
Educators should know by now which is the best method, lectures or small group discussions.	
Learning definitions word-for-word is often necessary to do well on tests.	
Most words have one clear meaning.	
It's a waste of time to work on problems which have no possibility of coming out with a clear-cut and unambiguous answer.	
If scientists try hard enough, they can find the truth to almost everything.	
Scientists can ultimately get to the truth.	
If teachers would stick more to the facts and talk less about ideas, one could get more out of college.	
Almost all the information you can learn from a textbook you will get during the first reading.	
If you are ever going to be able to understand something, it will make sense to you the first time you hear it.	
If a person tries too hard to understand a problem, he or she will most likely end up being confused.	

Note. Individual items were rated on a 1–5 Likert-type scale; high scores indicate agreement with less sophisticated beliefs.

[a] Scale adapted from Schommer (1992) and Qian and Alvermann (1995).

liefs questionnaire did not indicate that these dimensions emerged either as two distinct factors, as suggested by Schommer (1994), nor did the analyses replicate the one-factor solution, as found by Qian and Alvermann (1995) in their use of the instrument. (The overall four-factor solution that emerged from an item-based factor analysis had no single factor that replicated those factors reported by Schommer and others when a factor analysis is conducted using subscales.) In order to develop a scale for comparison to the dimensions indicated by the new instrument, those items used by Qian and Alvermann (1995) were selected, with a resulting scale of 11 items ($\alpha = .66$) and identified as ''certain/simple knowledge'' (Table 3).

Correlations among the dimensions were also examined. These correlations (Table 4) indicate that the general certain/simple knowledge dimension is significantly correlated with three of the four dimensions (all but justification) in both science and psychology (with certainty in psychology, $r = .48$; with certainty in science, $r = .35$; with source in psychology, $r = .21$; with source in science, $r = .18$; with attainability of truth in both disciplines, $r = .24$).

TABLE 4
Correlations among Dimensions of Epistemological Beliefs

Variable	1	2	3	4	5	6	7	8	9
Discipline-focused beliefs									
Psychology									
1. Cert./simp.	—								
2. Justif: personal	−.19	—							
3. Source: authority	.34**	−.10	—						
4. Attain. of truth	.20**	−.11*	.16*	—					
Science									
5. Cert./simp.	.35**	.01	.05	.11*	—				
6. Justif: personal	.09	.31**	.04	.05	−.35**	—			
7. Source: authority	.02	.14*	.29**	−.02	.54**	−.33**	—		
8. Attain. of truth	−.01	.08	−.01	.53**	.28**	−.17**	.24**	—	
General beliefs									
9. Cert./simp.	.48**	.02	.21**	.24**	.35**	.11	.18**	.24**	—

Note. High scores indicate agreement with less sophisticated beliefs. ($N = 326$).
* $p < .05$.
** $p < .01$.

TABLE 5
Means and Standard Deviations for Epistemological Beliefs Scales by Discipline

	Psychology	Science
Scale	*M* (*SD*)	*M* (*SD*)
Discipline-focused epistemological beliefs		
Certainty/simplicity of knowledge	1.78 (.52)	2.37 (.78)***
Justification for knowing: personal	3.31 (.65)	2.74 (.70)***
Source of knowledge: authority	2.55 (.61)	3.19 (.76)***
Attainability of truth	2.60 (.79)	3.00 (.92)***

Note. Individual items were rated on a 1–5 Likert-type scale; high scores indicate agreement with less sophisticated beliefs ($N = 326$).

*** Significant difference between scales by discipline at $<.001$ level.

Disciplinary Differences in Epistemological Theories

The second research question regarded disciplinary differences in epistemological theories. A comparison of the mean responses for each of these dimensions indicated that although the structure of beliefs was similar across disciplines, students did have different epistemological perceptions of the disciplines of science and psychology. To conduct these analyses, I used dependent *t* tests with a more conservative alpha, adjusted to .01 to control for Type 1 error.

Results indicate that there are highly significant differences by discipline (Table 5) for each of the four scales: certainty/simplicity of knowledge [$t(325) = -14.63$, $p < .001$]; justification for knowing: personal [$t(325) = 13.01$, $p < .001$]; source of knowledge: authority [$t(325) = -13.85$, $p < .001$]; and attainability of truth [$t(325) = -8.57$, $p < .001$]. These indicated that students saw knowledge in science as more certain and unchanging than in psychology; were more likely to regard personal knowledge and firsthand experience as a basis for justification of knowing in psychology than in science; viewed authority and expertise as the source of knowledge more in science than in psychology; and perceived that in science, more than in psychology, truth is attainable by experts.

Correlations among the scales (Table 4) indicated that each of the dimensions was significantly correlated across discipline. Thus, correlations were significant between science and psychology for certainty/simplicity of knowledge ($r = .35$), for justification for knowing ($r = .31$), for source of knowledge ($r = .29$), and for attainability of truth ($r = .53$). Although these correlations were significant, the fact that they were of only moderate size suggests that there were intraindividual differences regarding perceptions of the dimensions of epistemological theories.

Academic Major and Personal Epistemology

In order to examine the relation of academic major to personal epistemology, I conducted a repeated-measures multivariate analysis of variance (MANOVA), creating four two-level dependent variables to compare the disciplinary beliefs (Discipline) of students majoring in social science with those majoring in science (Table 6). Results indicated no significant multivariate effects, but at the univariate level there was an effect of major for attainability of truth, with students majoring in science significantly more likely than those majoring in social science to view truth as attainable [$t(243) = 2.28$, $p < .05$].

Independent *t* tests between majors on the certainty/simplicity scale from the general epistemological beliefs instrument indicated no significant differences by major (for science majors, $M = 2.35$, $SD = .45$; for social science majors, $M = 2.26$, $SD = .45$).

Gender Differences in Personal Epistemology

Gender differences in personal epistemology were also examined with a repeated-measures multivariate analysis of variance (MANOVA). There were no multivariate effects, but there was a univariate effect of gender for both certainty/simplicity of knowledge [$t(319) = 3.21$, $p < .01$] and source of knowledge [$t(319) = 2.37$; $p < .05$)]. As indicated in Table 7, this indicated that men were more likely than women to see knowledge as certain and unchanging. In regard to source of knowledge, men were significantly more likely than women to view authority and expertise as the source of knowledge. Independent *t* tests between genders on the general measure of certainty/simplicity scale indicated similar significant differences [for males, $M = 2.44$, $SD = .48$; for females, $M = 2.24$, $SD = .47$, $t(311) = 3.64$, $p < .001$].

Epistemological Theories and Academic Performance

In order to examine the relationship between academic performance and epistemological theories, students' grades in psychology and in a natural science course, as well as their overall grade point average for the semester, were correlated with each of the dimensions on each of the scales (see Table 8). The overall pattern, as predicted, showed negative correlations between grades and both discipline-specific and general epistemological beliefs. Several of these were statistically significant correlations. In regard to the discipline-focused beliefs, students' beliefs in the certainty and simplicity of knowledge in psychology had a significant negative correlation with both their end-of-term grade in psychology ($r = -.31$) and their GPA ($r = -.22$). A similar but slightly different pattern was evident for beliefs about

TABLE 6
Differences in Discipline-Focused Epistemological Beliefs by Major

	Psychology		Science	
Scale	Science majors (N = 125) M (SD)	Social science majors (N = 123) M (SD)	Science majors M (SD)	Social science majors M (SD)
Discipline-focused epistemological beliefs				
Certainty/simplicity	1.74 (.46)	1.68 (.48)	2.39 (.69)	2.28 (.65)
Justification: personal	3.37 (.62)	3.27 (.68)	2.70 (.66)	2.67 (.70)
Source: authority	2.56 (.60)	2.50 (.61)	3.22 (.75)	3.19 (.76)
Attainability of truth	2.68 (.76)	2.51 (.84)	3.14 (.87)	2.88 (.92)

Note. The remaining students in the sample were majoring in areas other than science or social science. Individual items were rated on a 1–5 Likert-type scale; high scores indicate agreement with less sophisticated beliefs (N = 248).

TABLE 7
Gender Differences in Epistemological Beliefs by Discipline

	Psychology		Science	
	Males (N = 152)	Females (N = 172)	Males	Females
Scale	M (SD)	M (SD)	M (SD)	M (SD)
Discipline-focused epistemological beliefs				
Certainty/simplicity	1.86 (.54)	1.71 (.50)	2.48 (.69)	2.27 (.75)
Justification: personal	3.33 (.60)	3.29 (.70)	2.73 (.66)	2.74 (.73)
Source: authority	2.60 (.67)	2.51 (.57)	3.29 (.64)	3.09 (.66)
Attainability of truth	2.53 (.83)	2.66 (.75)	3.00 (.95)	2.99 (.91)

Note. Individual items were rated on a 1–5 Likert-type scale; high scores indicate agreement with less sophisticated beliefs (N = 324).

TABLE 8
Correlations between Grades and Dimensions of Epistemological Beliefs

Dimension	Science grade (N = 147)	Psych grade (N = 311)	GPA (N = 297)
Discipline-focused epistemological beliefs			
Psychology			
1. Certainty/simplicity	−.13	−.31**	−.22**
2. Justification: personal	−.14	−.06	−.08
3. Source: authority	−.07	−.01	.01
4. Attainability of truth	−.06	−.12*	−.14*
Science			
5. Certainty/simplicity	−.11	−.18**	−.12*
6. Justification: personal	−.01	−.07	−.09
7. Source: authority	−.09	−.04	−.02
8. Attainability of truth	−.16	−.08	−.11
General epistemological beliefs			
9. Certainty/simplicity	−.17*	−.31**	−.28**
Mean (SD) of grades	2.83 (.84)	3.14 (.76)	3.10 (.61)

Note. High scores indicate agreement with less sophisticated beliefs. Grades are based on a 0–4 scale, with 0 = E, 4 = A (N = 326).
* $p < .05$.
** $p < .01$.

certainty/simplicity of knowledge in science, as in this case beliefs about science were significantly correlated with grade in psychology ($r = -.18$) and with GPA ($r = -.12$). The certainty/simplicity scale from the general epistemological beliefs questionnaire significantly correlated with grades in both psychology ($r = -.31$) and science ($r = -.17$) as well as GPA ($r = -.28$). Overall, these results provide some confirmation of the relation between beliefs and academic performance, at least in regard to the dimension of certainty/simplicity of knowledge.

DISCUSSION

A review of the literature on epistemological development and epistemological beliefs (Hofer & Pintrich, 1997) suggested that there are four underlying dimensions of personal epistemology: certainty of knowledge, simplicity of knowledge, justification for knowing, and source of knowledge. One primary objective of this study was to seek evidence for each of the dimensions in this model of epistemological theories. Four distinct factors emerged, providing some support for the proposed model as well as directions for further research. Each of these four factors is discussed in turn.

Certainty of knowledge and simplicity of knowledge did not appear as one dimension, but merged, quite similar to the finding of Qian and Alvermann (1995) in their factor analysis of the revised Schommer Epistemological Beliefs Questionnaire. It is possible that the removal of some items from the original questionnaire may have contributed to the merging of these dimensions, as Qian and Alvermann (1995) also note. However, it may be that these are not two distinct dimensions but are representative of one cluster of beliefs about knowledge. If viewed as a continuum, knowledge at one end would be viewed as discrete elements that are known with certainty; at the other end, knowledge would be more complex and interwoven, subject to greater interpretation. It is also plausible that individuals can conceptually distinguish the two dimensions but that the dimensions do not operate independently. Further investigation is necessary, including more item-based factor-analytic studies with the Schommer instrument. It appears that most of the studies which have identified separate dimensions of certainty and simplicity have used predetermined subsets of items in the factor analysis (Schommer, 1990, 1993a, 1993b; see Hofer & Pintrich, 1997, for further analysis of this issue).

Justification for knowing did appear as a factor, but those items that loaded represented one particular facet of items hypothesized for this dimension. These items suggest a view of justification that values 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''). Since justification has been more broadly conceptualized in the existing literature (King & Kitchener, 1994), this area

needs further investigation. It is possible that those items written to tap justification but which did not load accordingly either were poor measures of the construct or that students are less capable at this particular age of interpreting the meaning of those items that address more sophisticated aspects of the justification for knowing.

Similarly, source of knowledge represents only that facet of the dimension in which external authority and recognized expertise are the most valuable sources. The items which loaded on this factor (e.g., ''Sometimes you just have to accept answers from the experts even if you don't understand them'' and ''If you read something in a textbook for this subject, you can be sure it's true'') suggest that such sources can be accepted and trusted without question. Although this does appear similar to the source of knowledge as described by Schommer (1994) and entitled in its naive form as ''Omniscient Authority,'' this omits much of the conceptual contribution made by Belenky et al. (1996) and Baxter Magolda to defining this dimension. This would include a view of the individual as a constructor of meaning and as a more active participant in the process of knowing.

These two factors, justification for knowing and source of knowledge, appear in some sense to represent two distinct positions and were, in fact, negatively correlated within the disciplines. It is notable that with both factors the items that loaded were written as low-level beliefs and that the reverse items did not load. This raises some general concerns about the difficulty of rating beliefs on a Likert-type scale; it may be possible that some items are not yet meaningful to 1st-year college students, who perhaps could not be expected to understand the full range of epistemological perspectives of each of these dimensions. This is consistent with a developmental Piagetian framework in that students would not be expected to adequately interpret more than one stage beyond their current perspective. This may also affirm the position that interviewing is a preferable means of eliciting such beliefs. Paper-and-pencil measurements of personal epistemology continue to play an important role in research on how beliefs and theories about knowledge and knowing influence academic learning, but we may need to venture beyond Likert-type scales for more breadth of assessment.

An additional factor emerged that was not hypothesized, which was labeled ''attainability of truth.'' Although these items seemed possibly related to the certainty of knowledge (e.g., ''Experts in this field can ultimately get to the truth''), the items did not load with that factor. Conceptually they would appear to be aspects of the same construct; thus it is unclear why the factor loadings do not suggest this. The two dimensions, certainty/simplicity and attainability of truth, do correlate positively within each of the disciplines, however. Future studies with the instrument are needed to see how consistently this factor appears. There are also other interpretations of the factor structure that emerged. Elimination of those items that load on more

than one factor indicates, for example, that the certainty/simplicity factor is more specifically about certainty than simplicity; this needs further attention as this and similar instruments are refined.

In order to assess the validity of the new instrument, correlations were examined with comparable dimensions from existing instruments. Correlations between the certainty/simplicity dimension on the new instrument and the same dimension on the general measure of epistemological beliefs suggest that these instruments may be tapping a similar dimension.

In regard to the second research question about disciplinary differences, this study presents evidence that there is an underlying dimensionality to epistemological beliefs that cuts across disciplinary domains, but that students do hold differing epistemological beliefs about ''disciplines'' such as science and psychology.[3] The same factor structure appears in both disciplines and similar factors correlate across disciplines, but the mean responses by discipline differ significantly. This suggests that there is an underlying set of epistemological beliefs, but that students, at least by the 1st year of college, discriminate as to how these beliefs differ by discipline. As such, this contradicts previous findings of Schommer and Walker (1995), who called for more research in this area, stating that ''for now, it appears that researchers may assume that epistemological beliefs tend to be domain independent among college students in their early years'' (p. 430). A primary distinction between this study and that of Schommer and Walker (1995) was the difference in the instruments used to measure epistemological beliefs. Although in that study participants were explicitly told to keep a discipline in mind, the questions were descriptive of general beliefs. In this study, the items were written to more directly address specific beliefs about knowledge and knowing, and each of the items was phrased in a way that was discipline focused. The findings in this study are probably consistent with broader conceptualizations of the disciplines as having underlying epistemological distinctions (Becher, 1989; Donald, 1986, 1990, 1995; Schwab, 1964, 1978) and suggest that 1st-year college students are capable of making these distinctions.

We need to know more about how early such disciplinary distinctions emerge, how students begin to distinguish disciplinary beliefs from more general epistemological beliefs, and how these beliefs interact. An additional research question that needs attention is how individuals develop and refine their beliefs as disciplinary expertise grows and how classroom practices shape this process. Interview and observational studies may prove more fruitful to answer these types of questions. Expert-novice studies at multiple lev-

[3] I apologize to fellow psychologists for this problematic categorization of ''disciplines.'' Students in this study were all enrolled in a course that deliberately presented psychology as both a social science and a natural science.

els of professional development within and across disciplines could also prove useful in this area. Further work on epistemological beliefs and domain differences may be of value in helping instructors understand how students approach learning within the disciplines and may prove useful in providing a link to understanding student learning strategies and academic performance.

A further concern is raised by the finding of mean differences by discipline on each of the dimensions. A strict interpretation of these results, based on the schemes from which these measures were derived, would lead to the conclusion that, on the whole, students hold less sophisticated beliefs about science than about psychology, as each of these systems of measurement posits a continuum of beliefs and mean scores were generally lower in science. Their beliefs that knowledge in science is more certain than in social science, for example, would be interpreted as evidence of lesser sophistication or of a lower stage of epistemological development. It seems far more likely that these students are representing views of the disciplines that would be widely shared among professionals as well. This calls into question the degree to which such measures are appropriate in assessing disciplinary differences and the extent to which a continuum of beliefs or stage sequences are the best means of conceptualizing these differences, at least to the extent that such a continuum is interpreted as a representation of intellectual sophistication or individual development. A recognition of the epistemological distinctions of the disciplines might imply a level of intellectual sophistication in itself, but this framework for studying personal epistemology cannot capture such distinctions and we need measures that can.

Furthermore, more work is needed to address the contextuality of beliefs and the degree to which each of us make epistemic judgments appropriate to context about the certainty of particular information, the credibility of the source, and the methods of justification. How do such judgments differ depending on the situation, our prior knowledge base, our needs, and our purpose as learners? Do they differ when we learn a new subject, read outside our discipline, or consult with experts in unfamiliar fields? And would such differences imply a change in our beliefs, less sophistication, or a more nuanced appreciation of the context? Perhaps it is just such adaptability that is a hallmark of greater epistemological awareness. More work is needed to understand flexibility in epistemic thinking within each of the dimensions and the role that context and purpose play.

Gender differences in personal epistemology continue to merit further study. This research suggests that among 1st-year college students women are less likely than men to see knowledge as certain and are less likely to rely on authority. While this represents evidence of greater sophistication of epistemological beliefs as measured in this study, it is worth exploring in more depth to understand both the origins of this difference and the interactions of these beliefs with the 1st-year college experience. Existing literature

on gender differences in personal epistemology suggests that while there are not uniformly different ways of knowing and perceiving knowledge, there may be some patterns that are gender related (see, for example, Baxter Magolda, 1992). The finding that there were gender differences on some dimensions but not others may fit within this framework. Explorations of gender differences by dimension may lead to greater specificity about the nature of these differences than gender differences in more global measures, such as stages of reflective judgment (King & Kitchener, 1994), would indicate.

In regard to the relation of major and epistemological beliefs among these students, those majoring in natural science were significantly more likely than those majoring in social science to view truth as attainable. This seems consistent with the findings of both Jehng et al. (1994) and Paulsen and Wells (1998) regarding students' perceptions of the disciplines, but suggests that students self-selecting into scientific fields of study are even more likely to hold these beliefs than those choosing social sciences. Clearly there is a need for pursuing this question with students at different levels of study. We need to know whether course-taking patterns shape beliefs and, if so, at what level of study this is likely to become significant. It is also possible that some beliefs, for example, about certainty, are more representative of personal characteristics that lead students to select themselves into science or perhaps whether there is an interaction between personal characteristics (e.g., need for certainty) and acculturation into the disciplines.

As expected, epistemological beliefs, at least on the dimension of certainty/simplicity of knowledge, are correlated with academic performance. This was the case whether the dimension was discipline specific or general. Overall, this particular dimension seems the most coherent one to measure and may prove to be the one with the most predictive power among 1st-year college students. These findings also suggest the value of a general measure of epistemological beliefs. The linkage between academic performance and epistemological beliefs has been documented previously (Schommer, 1993b) and continued work is needed to understand the mechanisms by which this occurs and the nature of the mediating variables. We need further studies that explore the possible linkages between motivation, cognition, learning strategies, and epistemological beliefs.

In conclusion, this study provides an initial attempt to empirically test the dimensions of epistemological theories as identified across the literature (Hofer & Pintrich, 1997). More work is needed to flesh out these dimensions in self-report measures so that further studies can be done to tap the relation between epistemological theories and other aspects of academic learning. Disciplinary differences in epistemological theories between science and psychology were highly significant, a finding contradictory to previous research. The new instrument used to measure these differences needs further validation and piloting in other disciplines, but this study does suggest that

it may be preferable to assess these differences with instruments focused on particular disciplines rather than use domain-general instrumentation, although domain-general instruments may prove more useful in other types of studies.

There are broader concerns about the study of personal epistemology that need to be addressed in future work. Although there has been considerable research in this area, there are still large conceptual differences in the various approaches, and the underlying distinctions may represent fundamentally different understanding of the constructs. Whether these need to be reconciled, or whether they need to be further elaborated and codified in order to enrich our understanding of personal epistemology, merits more discussion among researchers.

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