ABSTRACT

Title of dissertation: AT THE CROSSROADS OF EPISTEMOLOGY AND MOTIVATION: MODELING THE RELATIONS BETWEEN STUDENTS' DOMAIN-SPECIFIC EPISTEMOLOGICAL BELIEFS, ACHIEVEMENT MOTIVATION, AND TASK PERFORMANCE

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Within the educational literature, students' epistemological beliefs (i.e., beliefs about the nature of knowledge) have been examined in relation to a variety of cognitive learning outcomes (e.g., strategy use and academic performance). However, relatively few investigations have explored the relations between students' epistemological beliefs and achievement motivation. In this investigation, a model of the potential relations between epistemological beliefs, achievement motivation, and learning outcomes was proposed and a portion of the model was tested. Specifically, I focused on the domain-specific epistemological beliefs, ability beliefs, expectancies for success, achievement value, intentions, and task performance of college students.

Four-hundred and eighty-two students completed measures designed to assess students' a) beliefs about the structure, stability, and source of knowledge, b) ability beliefs, c) expectancies for success, d) achievement values, and e) intentions to engage in future tasks relative to history and mathematics. Students also completed a learning task related to history and mathematics. The learning task involved reading a two-part passage that described the history and mathematics of statistical regression. After reading each portion of the passage, participants reported the strategies they used. Students also completed knowledge tests designed to assess what they learned.

Separate confirmatory factor analyses were conducted to determine the structure of students' epistemological beliefs, ability beliefs and expectancies for success, and achievement values. Findings supported the domain-specific and multidimensional nature of epistemological beliefs and suggested the presence of underlying domain-general beliefs. Additionally, previous findings with respect to the structure of students' ability beliefs, expectancies for success, and achievement values were replicated (e.g., Wigfield & Eccles, 2000). Separate structural equation models were applied to the history and mathematics data to assess the proposed relations between epistemological beliefs, achievement motivation, and learning outcomes. Evidence supported many of the hypothesized relations. For instance, students' epistemological beliefs significantly influenced their competency beliefs, achievement values, and some forms of strategy use. Relations between competency beliefs, achievement values, task performance, and intentions were also confirmed. These findings indicate the need for additional research examining the relations between epistemological beliefs and motivation and highlight the practical significance of students' epistemological beliefs.

AT THE CROSSROADS OF EPISTEMOLOGY AND MOTIVATION: MODELING THE RELATIONS BETWEEN STUDENTS' DOMAIN-SPECIFIC EPISTEMOLOGICAL BELIEFS, ACHIEVEMENT MOTIVATION, AND TASK PERFORMANCE

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CHAPTER I

INTRODUCTION

On a daily basis, our beliefs about people, events, and objects guide our behaviors and influence us to act in specific ways. This is no less true in educational settings. Students' perceptions of their own abilities, the perceived feelings and beliefs of others (e.g., teachers) and beliefs about the learning tasks affect their behavior and subsequent performance. In recent decades, educational and psychological literatures have begun to consider the role of students' beliefs about knowledge (i.e., their epistemological beliefs) in the learning process. Philosophical debates about epistemological issues date back to ancient times when Plato defined knowledge as *justified true belief* (e.g., Scheffler, 1965). However, the more recent discussions have been marked by a specific interest in the epistemological beliefs of students. Thus far, the literature has primarily focused on the nature of students' knowledge beliefs, as well as how those beliefs relate to other salient variables. (e.g., strategy use, conceptual change, and academic performance; Hofer, 2000; Qian & Alvermann, 1995; Schommer, Crouse, & Rhodes, 1992)

William Perry (1970) is credited with being one of the first researchers to examine students' beliefs about knowledge empirically. Since his original work (Perry, 1970), there have been multiple shifts in the way researchers conceptualize students' beliefs about knowledge. For example, students' epistemological beliefs were once viewed as a unidimensional construct (e.g., Baxter Magolda, 1992). Students' epistemological beliefs are now conceptualized as a system of beliefs, in which students hold various beliefs about the different dimensions of knowledge (e.g., Schommer, 1990). The various dimensions of students' knowledge beliefs are believed to develop and emerge at different rates. Further, within this asynchronous view of epistemological beliefs, belief dimensions reflective of philosophical discussions of knowledge are apparent. For instance, beliefs about the certainty, justification, and source of knowledge have emerged (e.g., Hofer, 2000). Additionally, within the educational literature, the conceptualizations of students' epistemological beliefs have become more contextualized and studied with regard to specific bodies of knowledge. As evidence of this, various programs of research have emerged exploring students' beliefs about knowledge relative to a particular academic domain of study (e.g., Carey, Evans, Honda, Jay, & Unger, 1989; Hofer, 2000). The contextualization of students' epistemological beliefs is reflective of the current movement in the educational and psychological literatures to situate the learning process in the broader context.

Developments are also apparent with respect to how researchers measure and assess students' beliefs about knowledge. These developments are reflective of the way in which beliefs are conceptualized. For instance, researchers interested in crafting rich in-depth portraits of students' knowledge beliefs typically used interviews and open-ended questionnaires to gather data (e.g., Baxter Magolda, 1992; King & Kitchener, 1994). However, these descriptions often tend to take more of a unidimensional and synchronous approach to students' epistemological beliefs. Those who have adopted a multidimensional perspective of epistemological beliefs have relied on Likert scale items that assess the various aspects of knowledge (e.g., Schommer, 1990). Although there is some variability in the belief factors that emerge from these measures, the emergent factors can typically be classified into the following five categories: Beliefs about the Structure of Knowledge; Beliefs about the Stability of Knowledge; Beliefs about the

Source of Knowledge; Beliefs about the Nature of Knowledge Acquisition; and Beliefs about the Ability to Acquire Knowledge.

As researchers developed the means to assess students' beliefs about knowledge, they began to study those beliefs in relation to various learner characteristics and learning outcomes. For instance, students' beliefs about knowledge appear to develop with age and education (e.g., Schommer, 1993a; Schommer, Calvert, Gariglietti, Baja, 1997). Researchers have also examined epistemological beliefs in relation to other characteristics such as gender, culture, and home environment (e.g., Baxter Magolda, 1992; Schommer, 1990; Youn, 2000). Additionally, evidence suggests that students' experiences within specific learning environment may affect how students view and relate to knowledge (Qian & Alvermann, 1995; Schommer 1993a; Schommer et al., 1992).

Students' epistemological beliefs have also been examined in relation to a host of learning processes and outcomes. For example, higher levels of strategy use, comprehension, conceptual change, and academic performance are associated with what researchers view as more sophisticated beliefs about knowledge (i.e., knowledge is tentative, complex, and derived by reason and personal experience; e.g., Hofer, 2000; Kardash & Howell, 2000; Qian & Alvermann, 1995; Rukavina & Daneman, 1996). Such investigations suggest that students' beliefs may also interact with the learning environment such that the extent to which a task optimally supports student learning depends on students' initial conceptualizations and beliefs about knowledge (e.g., Tsai, 1999b; Windschitl & Andre, 1998). Examined collectively, this body of work suggests that students' epistemological beliefs are a key aspect of students' academic belief systems.

Much of the current research that examines epistemological beliefs in relation to other constructs tends to focus on various cognitive learning outcomes (e.g., strategy use and academic achievement), while other essential aspects of the learning process (e.g., motivation) are neglected. To a certain extent this is to be expected. That is, when a new avenue of research emerges, a critical mass must develop with respect to how the construct is conceptualized, assessed, and studied in relation to other variables before all possible connections can be considered. Even so, a review of the literature suggests that the time has come to explore students' epistemological beliefs in relation to their achievement motivations.

In particular, examination of three prominent approaches to motivation (i.e., goal orientation theory, self-efficacy, and expectancy-value theory) reveals that there are several potential links between students' beliefs about knowledge and their motivations to achieve in school environments. For example, academic goal orientations are viewed as students' guiding reasons for engaging in achievement behavior (e.g., Ames, 1992; Nicholls, 1989). Students' goal orientations are significantly related to their task choice, persistence, strategy use, and academic achievement (e.g., Ames, 1992; Anderman & Maehr, 1994).

Dweck (e.g., Dweck & Leggettt, 1988) has proposed that students' goals are derived from students' belief systems. In her work, Dweck (e.g., Elliot & Dweck, 1988) has explored students' beliefs about intelligence in relation to their goal orientations. Students' beliefs about knowledge may also be a powerful factor in the formation of students' approaches to achievement situations. The few empirical investigations that have examined epistemological beliefs and goal orientations together have indicated that they are related (e.g., Hofer, 1999; Qian & Burrus, 1996). For instance, students who recognize the complexity of knowledge and believe that learning requires time and effort tend to adopt the more adaptive mastery (task or learning) goal orientations. In contrast, students who view knowledge as isolated and believe that learning is a process that occurs quickly tend to adopt performance (ego or ability) goal orientations (Paulsen & Feldman, 1999).

Within the motivation literature, students’ beliefs about their competencies (i.e., self-efficacy, expectancies for success, and ability beliefs) have been identified as important determinants of their academic motivation and behavior. The distinctions between these constructs are discussed in detail in Chapter 2. However, they each pertain to an aspect of students’ beliefs about what they can do. Consequently, they can be viewed collectively as competency beliefs. Further, such competency beliefs are related to choice of activity, persistence, effort, and strategy use (e.g., Bandura, 1997).

Specific theoretical links between students’ competency beliefs and epistemological beliefs are evident. Bandura (1997) states that self-efficacy is based on information from students’ mastery experiences, vicarious experiences, verbal persuasion, and physiological responses. Mastery and vicarious experiences offer students exposure to knowledge and the opportunity to form beliefs about the nature of that knowledge. Consequently, students’ perceptions of what knowledge is, viewed in relation to their beliefs about their own abilities, may affect their self-efficacy judgments for future learning tasks. Additionally, Eccles and Wigfield (e.g., Eccles et al., 1983;

Wigfield & Eccles, 2000) proposed a model in which students' expectancies for success are influenced by their goals and self-schemas. Students' ability beliefs and perceptions of task difficulty are two aspects of students' self-schema that may be linked to students' epistemological beliefs. That is, students' beliefs about the nature of knowledge in a specific domain may affect how difficult they believe the learning task will be. Previous research indicates that students' beliefs about knowledge are related to their competency beliefs (e.g., Hofer, 1999; Paulsen & Feldman, 1999).

Students' achievement values are an additional aspect of their achievement motivation that pertain to how different tasks meet students' needs. Within their model, Eccles and Wigfield (e.g., Eccles et al., 1983; Wigfield & Eccles, 2000) propose that there are four different types of achievement values (i.e., intrinsic value, importance value, utility value, and cost value). Further, while students' expectancy beliefs tend to be related to subsequent performance, achievement values are a significant predictor of students' future choices (e.g., Meece, Wigfield, & Eccles, 1990). Eccles and Wigfield suggest that students' values are derived from their self-schemas and their affective memories of past experiences. As previously discussed with respect to expectancy beliefs, students' epistemological beliefs may contribute to their task perceptions. Further, students' achievement values have been empirically related to their beliefs about knowledge (e.g., Enman & Lupart, 2000; Paulsen & Feldman, 1999)

Statement of Problem

While multiple studies have explored students' epistemological beliefs and achievement motivations in relation to various learning outcomes, few have examined the potential relation between students' knowledge beliefs and their motivations. Inspection of the proposed sources of students' goal orientations, competency beliefs (i.e., self-efficacy, ability beliefs, and expectancies for success), and achievement values suggests that students' beliefs about knowledge may contribute to these motivational beliefs. The few empirical studies that examined these constructs in relation to one another indicate that students' epistemological beliefs and motivation are related. However, this work is primarily correlational and exploratory (e.g., Hofer, 1999; Paulsen & Feldman, 1999). Relations among the constructs have not be explicitly specified or tested.

The paucity of research exploring epistemological beliefs and achievement motivation in relation to one another may be due, in part, to developments within each body of literature. For instance, within the epistemological belief literature, researchers initially focused on how epistemological beliefs are conceptualized and assessed. Although these are still concerns that are often debated, a multidimensional view of epistemological beliefs is prominent in the literature. There is also growing support for the domain-specificity of students' knowledge beliefs (see Buehl & Alexander, 2001; Hofer & Pintrich, 1997). However, despite these developments, or perhaps because of them, a host of epistemological belief factors have been identified through exploratory and confirmatory factor analyses. Although these factors can be classified into five broad categories (e.g., Beliefs about the Structure of Knowledge and Beliefs about the Stability of Knowledge), given the measurement issues that plague the epistemological belief research, additional research is needed to validate previous work and to more fully understand the dimensionality of students' epistemological beliefs.

The motivation literature has also witnessed developments with regard to how the various motivation constructs are conceptualized and assessed. For example, goal orientation theorists have discussed the utility of separating the approach and avoidance aspects of mastery and performance goals and examining them in relation to student behavior. Additionally, there is an on-going debate about what types of goal orientations are most adaptive for students' learning and achievement time (e.g., Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002; Midgley, Kaplan, & Middleton, 2001; Pintrich, 2000b). Within the expectancy-value literature, multiple studies (e.g., Eccles et al., 1983; Eccles & Wigfield, 1995; Meece et al., 1990; Wigfield et al., 1997) assessed aspects of the Eccles and Wigfield model and explored how the proposed constructs develop in elementary, middle-school, and high-school students. However, previous studies have not addressed the expectancies and values of college students. Additionally, Eccles and Wigfield have focused primarily on only three aspects of achievement value (i.e., intrinsic value, importance value, and utility value). Although cost value has received less attention in the literature, this aspect of value may be particularly salient for college students (e.g., Battle & Wigfield, 2003).

Purpose of Study

In response to the existing literature with respect to students' epistemological beliefs and achievement motivations, I proposed a working theoretical model of the relations between these constructs and their impact on students' strategy use, achievement, and future choices (Figure 1). The purpose of the current investigation was to assess a portion of this model. Specifically, I focused on the expectancy-value view of achievement motivation and explored the relations between students' domain-specific epistemological beliefs, ability beliefs, expectancies for success, achievement values, strategy use, performance, and future choices. Further, given the domain-specificity of students' knowledge beliefs, expectancies, and values, I examined students' beliefs and motivation relative to two academic domains: history and mathematics. These domains were selected because they represent a more well-structured domain (i.e., mathematics) and a more ill-structured domain (i.e., history). The proposed relations were examined in a sample of college students.

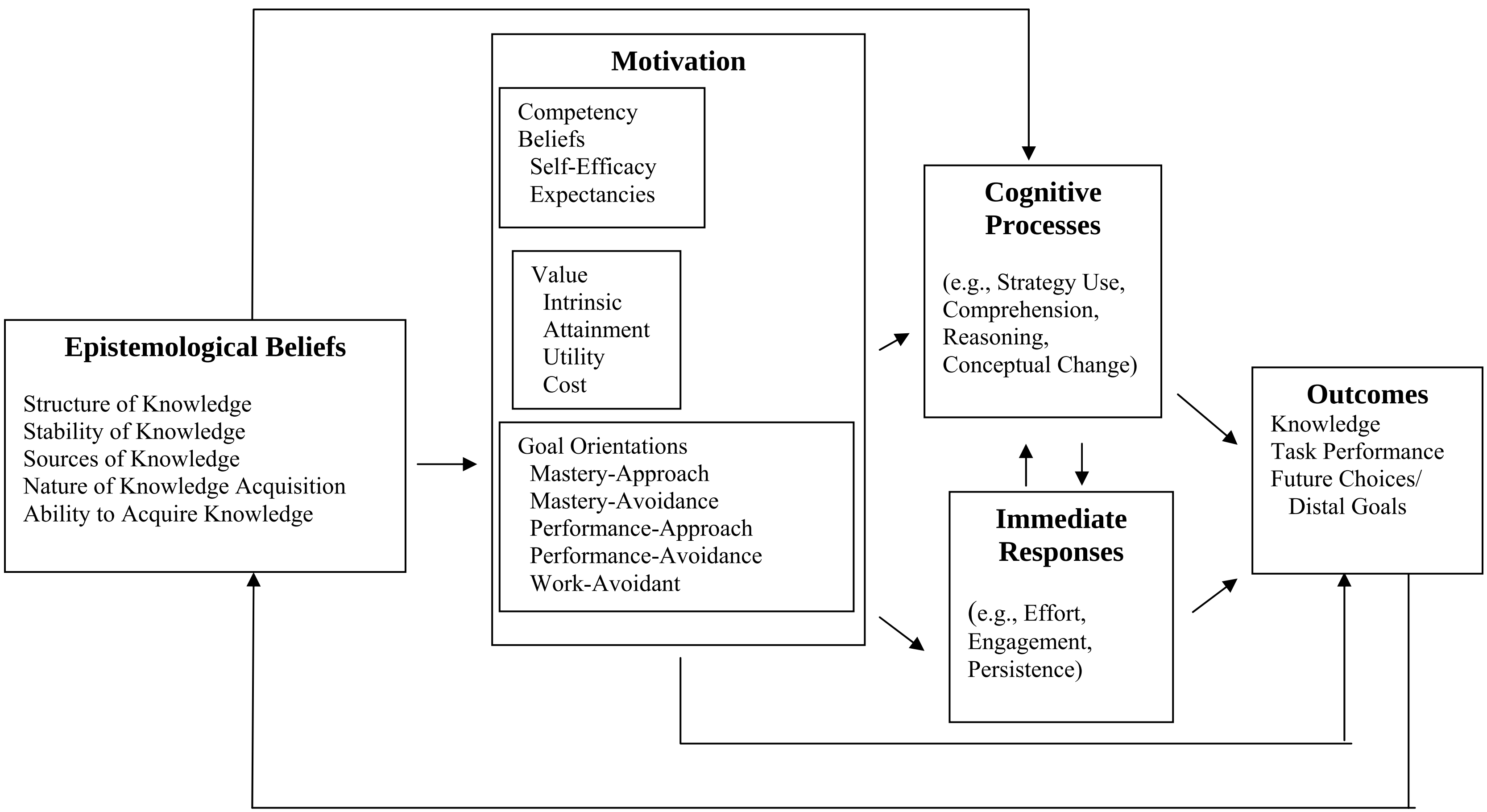
Overview of the Proposed Model

Figure 1 displays a working model of the potential relations between students' epistemological beliefs, motivation, and learning outcomes. This model was developed based on my review of the epistemological belief and motivation literatures, as well as my views and understandings of the constructs. Although I am primarily interested in students' knowledge beliefs, motivation, and learning, additional constructs were added to the model in an effort to reflect the current literature and explain how the constructs are related to one another.

Additionally, I view the current model (Figure 1) as being situated within an academic domain. Consequently, in presenting this model, I feel that it is important to acknowledge my assumptions about the specificity of epistemological beliefs. Specifically, I take a multidimensional and domain-specific approach to the study of epistemological beliefs. That is, I believe that there are various aspects or dimensions of students' epistemological beliefs and that students' epistemological beliefs differentiate by academic domains. Despite my domain-specific approach, I also hold that individuals possess general beliefs about knowledge that are reciprocally related to domain-specific beliefs. However, it is my contention that domain-specific beliefs are more relevant and exert a more direct influence on individuals' behavior in most situations.

Figure 1

Model of the Proposed Relations between Students' Epistemological Beliefs, Achievement Motivation, and Learning Outcomes



As my colleagues and I have discussed elsewhere (Buehl & Alexander, 2003), the situation will determine which types of beliefs (e.g., domain-general or domain-specific) are activated and guide students' behavior in a particular situation. Primarily when individuals interact with knowledge related to a domain with which they are familiar they are likely to refer to domain-specific epistemological beliefs. However, in a new and unfamiliar domain, individuals may rely on their more general conceptions of knowledge. Alternatively, if there are recognizable similarities between the new domain and a familiar domain, individuals may use their beliefs about knowledge in the known domain to guide their actions in the new domain. Thus, in my work, I focus on students' beliefs about knowledge in specific *academic* domains (i.e., bodies of knowledge typically taught in schooled settings).

With respect to empirical research, I believe, and evidence suggests (e.g., Buehl, Alexander, & Murphy, 2002; Hofer, 2000), that the emergence of domain-general and domain-specific beliefs depends on the measures used to assess individuals' epistemological beliefs. Domain-specific beliefs can only emerge when domain-specific measures are employed. Given the domain-specificity of epistemological beliefs and motivation, it is important to examine the relations between these constructs at a similar level of specificity. Research suggests that doing so makes it more likely for potential relations to emerge. For example, an examination of self-efficacy studies revealed that self-efficacy is more strongly related to student outcomes when the efficacy measures are more specific to the task at hand (Pajares, 1996). I believe that the same is true of the relation between students' knowledge beliefs, motivation, and learning outcomes.

In the following sections, I first discuss the constructs that were included in the model. I then provide a discussion of the proposed relations.

Components and Constructs in the Model

The model contains five main components: epistemological beliefs, motivation, cognitive processes, immediate responses, and learning outcomes. Specific constructs representing each of these components are also provided.

For *epistemological beliefs*, I have listed the five main categories of epistemological beliefs:

- Beliefs about the Structure of Knowledge (i.e., is knowledge simple or complex, isolated or integrated?)
- Beliefs about the Stability of Knowledge (i.e., is knowledge certain or tentative?)
- Beliefs about the Sources of Knowledge (i.e., does knowledge originate from an external source or personal experience?)
- Beliefs about the Nature of Knowledge Acquisition (i.e., is knowledge acquired quickly or gradually; is the process easy or effortful?)
- Beliefs about the Ability to Acquire Knowledge (i.e., is the ability to learn fixed or developed over time?)

I identified these categories of beliefs in my review of the current epistemological belief literature. The basis for these categories is detailed in Chapter 2. In the epistemological belief literature, there had been some debate as to whether Beliefs about the Nature of Knowledge Acquisition and Beliefs about the Ability to Acquire Knowledge are epistemological beliefs. However, I chose to include these categories in an effort to represent the current literature and to be as comprehensive as possible.

In contrast, for the other components of the model, I was somewhat less comprehensive and more selective, focusing on specific examples that appeared to be most related to students' epistemological beliefs. For instance, with respect to *achievement motivation*, I included goal orientation theory, competency beliefs (i.e., self-efficacy and expectancies for success), and achievement values in the model as examples of approaches to achievement motivation. I chose to focus on these approaches to motivation because they addressed two of the major issues in the motivation literature (i.e., students' beliefs about their abilities and students' reasoning for engaging in achievement behaviors). Previous works have related these forms of motivation to students' epistemological beliefs, and these approaches to motivation have been related to students' learning and achievement.

I also chose to include students' *cognitive processes* as a component in the model. For this component, I am referring to the processes students may use when they are engaged in process of learning, such as strategy use, comprehension, reasoning, and conceptual change. These specific examples (i.e., strategy use, comprehension, reasoning, and conceptual change) were selected because previous studies identified relations between them and epistemological beliefs, achievement motivation, and/or learning outcomes (e.g., Kardash & Howell, 2000; Ryan, 1984; Weinstein & Mayer, 1986). That is, in the literature, these processes appeared to be an important link between students' knowledge beliefs and motivations and their learning and achievement.

Within in the literature, a variety of non-cognitive factors (e.g., effort, engagement, and persistence) have been related to students' motivation and achievement. I wanted to include these factors in the model because they help explain the relation between motivation and achievement. Similar to the cognitive processes component, the specific non-cognitive factors were chosen due to their relations to students' motivation, learning, and achievement. As a way to group these factors together, I refer to them as *learning tactics and immediate responses*. This label is meant to encompass the non-cognitive aspects of the learning experience.

Finally, the model contains a component to represent students' *learning outcomes*. There are various types of outcomes that may result from a learning situation. Often times, knowledge gains or successful performance on future tasks are the expected outcome from a learning experience. However, the choices students make after a learning task (e.g., to engage in a task in the future or not), as well as their distal goals, can also be important outcomes from a learning experience. Consequently, I included cognitive and non-cognitive learning outcomes.

For each of the components in the model, with the exception of epistemological beliefs, I included examples of the constructs I felt were most relevant for developing a model to depict the relations between students' epistemological beliefs, achievement motivation, and learning outcomes. This model is not meant to be comprehensive. Instead, it represents an initial step to explicate how students' epistemological beliefs relate to the larger learning context. Potentially, future works can expand this model to include other aspects of motivation (e.g., self-determination theory; Ryan & Deci, 2000) and other constructs that are important to the learning process (e.g., social environment).

Proposed Relations

Direct influence of epistemological beliefs. In Figure 1, I propose various relations among the components just described. Students' epistemological beliefs are hypothesized to have a direct effect on their achievement motivation and their cognitive processes. That is, students' beliefs about the nature of knowledge may influence their motivation for academic tasks and the cognitive processes they use when they are engaged in these tasks. There is theoretical and empirical support for these proposed relations. I first address the potential links between epistemological beliefs and motivation and then turn my attention to the links between epistemological beliefs and cognitive processes.

With respect to motivation, the approaches I selected address whether students believe they can accomplish a task and if they want to do that task and why. In my view, students' beliefs about their abilities and their desire to engage in a learning task hinge on their perceptions of the task at hand. Within academic contexts, the tasks students encounter typically require them to acquire or manipulate knowledge in specific domains. Consequently, students' beliefs the nature of knowledge may color their perceptions of the task, thereby influencing motivation.

For instance, Dweck and Leggettt (1988) discussed how students' goal orientations are based, in part, on students' beliefs systems. Epistemological beliefs represent an aspect of students' belief systems that may be particularly important in learning and achievement situations. That is, students may be more inclined to adopt a particular goal orientation depending on their conceptualizations of knowledge in a particular domain. For example, a student, Greg, who views mathematics knowledge as complex and well-integrated with knowledge in other domains (i.e., a belief about the structure of knowledge) may be more likely to adopt a mastery goal orientation. In contrast, another student, Georgia, who conceptualizes mathematics knowledge as more isolated and compartmentalized may adopt a more performance goal orientation. Such predictions are supported by the findings of other empirical works (e.g., Hofer, 1999; Paulsen & Feldman, 1999).

In terms of students' self-efficacy beliefs, when students are asked about their ability to successfully complete a learning task, their judgments are likely to be based on their conceptions or misconceptions of knowledge and its acquisition. Consequently, students may consider their own abilities in relation to their conceptions of what knowledge is and what is needed to do well in acquiring that knowledge. For instance, students' beliefs about history knowledge may directly affect their competency beliefs with respect to constructing and acquiring knowledge from that domain (i.e., learning). That is, if a student, Sam, views history knowledge as isolated and compartmentalized (i.e., a belief about the structure of knowledge), and this student does not think that he is good at memorizing information, self-efficacy may be low. In contrast, if another student, Sally, views history knowledge as complex and well-integrated with knowledge from other domains and this student believes she is good at making connections and integrating information, she may have a higher level of self-efficacy. These proposed relations are supported by empirical evidence. Specifically, Hofer (1999), Neber and Schommer-Aikins (2002), and Paulsen and Feldman (1999) found that students with less sophisticated views of knowledge (i.e., knowledge is isolated) also tended to have lower levels of self-efficacy.

In their work with expectancy-value theory, Wigfield and Eccles (2000) noted that both value and expectancies for success are influenced by task specific beliefs. These beliefs include ability beliefs as well as the perceived difficulty of the task. Students' epistemological beliefs may serve as a foundation upon which students base the difficulty of tasks. Thus, I hypothesized that the specific relations between the epistemological belief factors and expectancy are similar to those between beliefs and self-efficacy.

Additionally, students' epistemological beliefs may also serve the foundation for how students value learning tasks. For instance, a student, Velma, may believe that knowledge in history is more uncertain and evolving (i.e., a belief about the stability of knowledge) and enjoy tackling problems that are more ambiguous. The proposed model predicts that her interest value in history would be higher than if she found such uncertainty distasteful and unsettling.

The model also proposes that students' epistemological beliefs have a direct influence on their cognitive processes. That is, students' conceptions of knowledge influence how they process information. Previous investigations have provided evidence of these relations (e.g., Ryan, 1984; Schommer et al., 1992). For example, students who viewed knowledge as more simplistic and isolated (i.e., a belief about the structure of knowledge) tended to use more naïve strategies (e.g., rehearsal) and fewer sophisticated strategies (i.e., elaboration) than students who viewed knowledge as more complex (Paulsen & Feldman, 1999).

<u>Indirect influences of epistemological beliefs.</u> In the model (Figure 1), epistemological beliefs do not have a direct influence on students' learning outcomes.

Instead the model suggests that epistemological beliefs indirectly affect learning outcomes via achievement motivation and cognitive processes.

Specifically, in the model, epistemological beliefs have a direct effect on achievement motivation. The model depicts achievement motivation as subsequently having a direct effect on students' cognitive process, learning tactics and immediate responses, and learning outcomes. These paths are supported by the current literature. For example, students with mastery goal orientations tend to use more sophisticated strategies, persist longer, exert more effort, and achieve more than students with performance goal orientations (e.g., Ames, 1992; Anderson & Maehr, 1994; Urdan, 1997). Similarly, higher levels of self-efficacy are related to strategy use, persistence, engagement, effort, and achievement (e.g., Pajares, 1996; Schunk, 1981; Zimmerman & Martinez-Pons, 1990). Achievement value has also been related to the choices students make with regard to future learning tasks (e.g., Eccles et al., 1983; Meece et al., 1990).

The model includes a direct path from cognitive processes to learning outcomes. Students' learning tactics and immediate responses are also hypothesized to influence their learning outcomes. Again, there is support for these paths in the current literature. For instance, students' strategy use, comprehension, and conceptual change are related to their subsequent learning and achievement (e.g., Weinstein & Mayer, 1986). Engagement, effort, and persistence have also been linked to knowledge gains and higher levels of achievement.

Additionally, the model suggests that students' cognitive processes are reciprocally related to their learning tactics and immediate responses (e.g., effort, engagement, and persistence). That is, the students' cognitive processes are likely to work in tandem with their learning tactics and immediate non-cognitive responses. For example, students' engagement in a learning task may influence their use of strategies. Alternatively, the process of comprehending a difficult text may require that students persist and exert considerable effort.

Domain-Specificity of the Proposed Model

As previously discussed, I take a domain-specific approach to the study of epistemological beliefs and I view the model view as functioning within specific academic domains. That is, variations in domain-specific epistemological beliefs may result in variations in students' motivation to pursue those domains as well as variations in performance across domains.

Academic domains are presumed to vary in terms of structure and content (Alexander, 1997; Frederickson, 1984). For instance, some domains tend to be more ill-structured whereas others are more well-structured. Ill-structured domains (e.g., history) address questions and problems that have multiple acceptable responses and numerous ways to reach those responses. Additionally, there is often disagreement among the experts in the domain as to what constitutes an appropriate response (Finke, Ward, & Smith, 1992).In contrast, well-structured domains (e.g., mathematics) tend to deal with questions and problems that have a clear set of appropriate responses, a limited number of ways to produce a correct answer, and clear-cut criterion to assess the appropriateness of responses (e.g., Alexander & Judy, 1988). Of course, to some extent, all domains address problems that are ill-structured and well-structured. Further, as individuals increase their expertise in a particular domain, they are also more likely to recognize and appreciate the complexity (i.e., ill-structuredness) of the domain. However, at the nonexpert level, most domains can be classified as being more ill-structured or more well-structured, while still possessing some elements of well-structuredness or ill-structuredness.

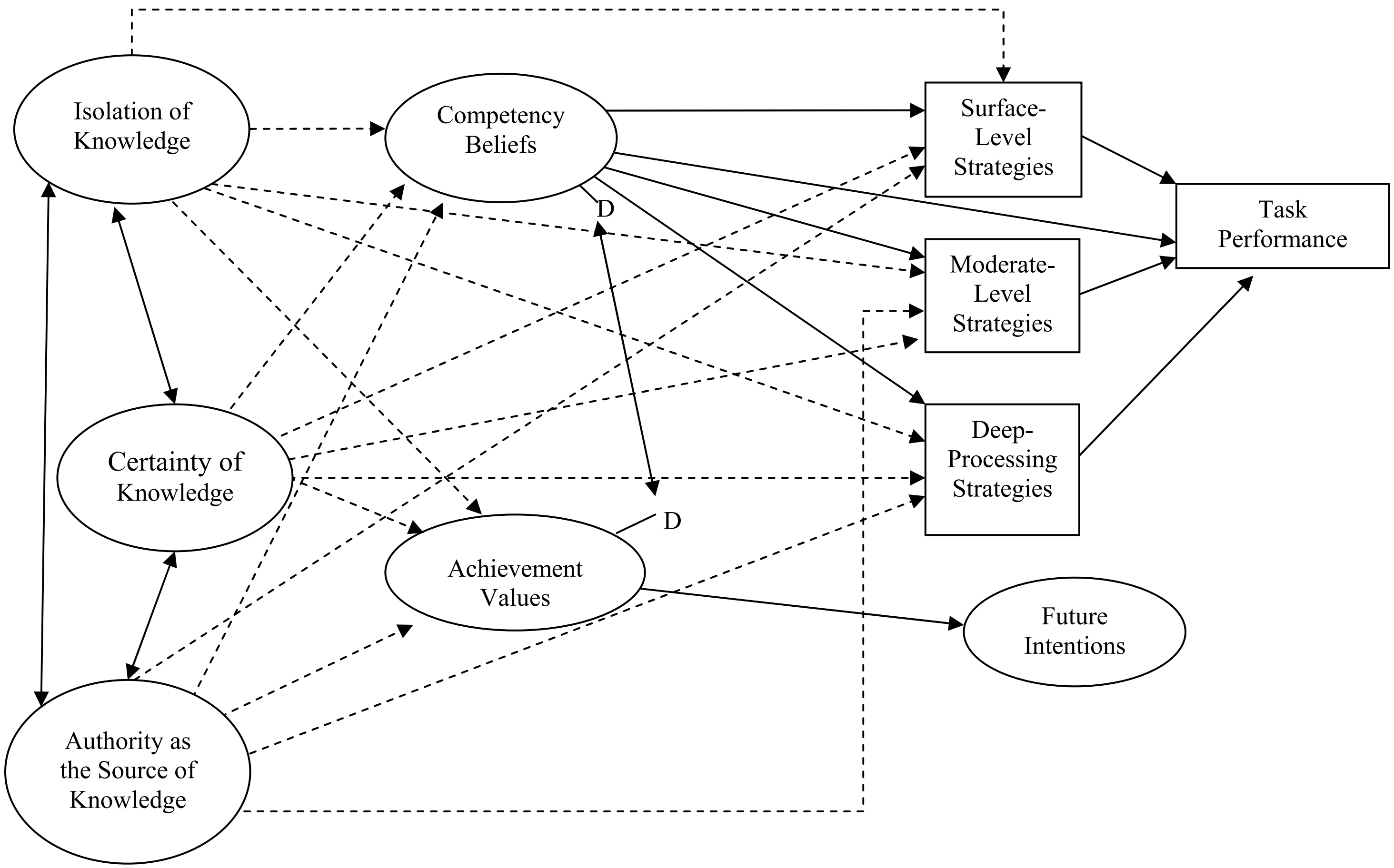
Despite these differences, the basic model is expected hold across domains, but, given the differences among domains, there may be some variation in the strength of the relations among the constructs. For example, students' beliefs about where knowledge comes from (i.e., a belief about the source of knowledge) may be most strongly related to their motivation in the context of history as opposed to mathematics. That is, students who view themselves as the source of knowledge may have stronger beliefs in their abilities to acquire and manipulate knowledge than students who view history knowledge as coming from an authority figure. The relation between students' beliefs about the source of mathematics knowledge and their motivation may not be as strong. Further, other knowledge beliefs may be more salient in the context of mathematics. For instance, beliefs about the structure may be particularly influential.

Overview of the Portion of the Model Assessed

For the current investigation, I assessed the viability of the proposed model. However, it was beyond the scope of the current study to include all aspects of the model. Consequently, I focused on a portion of the model and examined the relations among a specific subset of variables (Figure 2). In the following sections, I provide a justification for variables I selected and describe the paths I tested.

Figure 2

Hypothesized Structural Model



Note. Solid lines indicate paths hypothesized to be positive. Dotted lines indicate paths hypothesized to be negative.

Selected Variables

For the current investigation, I chose variables that were representative of students' epistemological beliefs, achievement motivation, cognitive processes, and learning outcomes. With regard to epistemological beliefs, I focused on students' beliefs related to the *structure of knowledge*, *stability of knowledge*, and *source of knowledge*. These are the most commonly agreed upon dimensions epistemological dimensions within the literature. Additionally, beliefs about these aspects of knowledge have been identified at a domain-specific level and related to students' academic achievement (e,g., Buehl et al., 2002; Hofer, 2000).

For achievement motivation, I focused on the constructs related to *expectancy-value theory*. In particular, I adopted the expectancy-value model proposed by Eccles and Wigfield (e.g., Eccles et al., 1983; Wigfield & Eccles, 2000). This choice was based on several factors. First, I wanted to choose motivation constructs that addressed students' beliefs about their abilities, as well as the reasons why they engage in achievement behaviors. The Eccles and Wigfield expectancy-value model fits this criterion. Specifically, their constructs related to students' ability beliefs and expectancies for success pertain to students' beliefs about their ability to be successful at a learning task. The value aspect of the model addresses the reasons why students may want to learn and achieve. Second, the Eccles and Wigfield model has previously been examined in relation to students' task performance and choices (e.g., Meece et al., 1990). Third, I perceived potential connections between the Eccles and Wigfield constructs and students' epistemological beliefs. Finally, although the Eccles and Wigfield model has been well explored with elementary, middle-school, and high-school students, little work has been done with college-age students. However, college is a time when students' competency beliefs and achievement values may have important academic (e.g., performance and course enrollment) and career implications (e.g., choice of major).

In their work, Eccles and Wigfield (e.g., Wigfield, 1994) make a conceptual distinction between students' beliefs about their abilities (i.e., *ability beliefs*) and their beliefs about they ability to do well on future tasks (i.e., *expectancies for success*). However, In this investigation, I determined that there was not empirical support for the theoretical distinction between ability beliefs and expectancies for success. Consequently, the constructs were collapsed into a single competency belief construct. Eccles and Wigfield also discuss four different aspects of achievement value (i.e., intrinsic, attainment, utility, and cost value). Previously work has found that intrinsic, attainment, and utility value tend to be highly interrelated whereas cost value has not been studied empirically in many studies. The current investigation offered an opportunity to explore the structure of these constructs in college students. However, given the strong relations among intrinsic, attainment, utility, and cost value, to assess the model these aspects of value were used to define a more general *achievement value* variable.

In the current investigation, students' cognitive processes were represented by *strategy use*. That is, I assessed the strategies students used when they engaged in a learning task. Based on the current strategy literature and analysis of the strategy data from this investigation, I examined students' use of *surface-level strategies* (e.g., rehearsal), *moderate-level strategies, deep-processing strategies* (e.g.. elaboration) separately. In contrast to the other variables discussed thus far, students' strategy use was included as a measured variable, not a latent variable.

Finally, in terms of learning outcomes, I included two different outcomes. First, I wanted to examine students' *learning and task performance*. To obtain a measure of students' learning, I assessed test students' knowledge before and after a learning activity (i.e., reading a text). This allowed me to gain a measure of what students' learned and examine it in relation to the other constructs in the model. In this investigation, learning was represented by the difference between students' pre-reading and post-reading knowledge scores (i.e., a knowledge gain score) and was a measured variable. Second, I wanted to examine students' *future intentions*. Consequently, I assessed students' intentions to engage in future learning activities related to history and mathematics.

As previously noted, I tend to take a domain-specific view of students' epistemological beliefs and motivation. Thus, all of the constructs were situated in two domains: history and mathematics. I expected the model to be appropriate for any academic domain. However, I also speculated that there may be some variation in the strength of the relations among the variables depending on the domain. Assessing the constructs in two domains allowed me to examine if there were differences across domains. Further, I chose history and mathematics because they represent domains that vary with respect to structuredness. That is, history represents a more ill-structured domain and mathematics represents a more well-structured domain. Additionally, based on university admission standards, students had relatively similar levels of exposure to the two domains.

Included Paths

The model assessed in this investigation included multiple paths to and from the constructs. In this section, I briefly walk through the model and explicate these potential relations.

First, based on previous findings, I proposed that the three dimensions of epistemological beliefs will be related to one another (i.e., covary). That is, I expected students' beliefs to be at a somewhat similar level of sophistication. For example, students who believe that knowledge well-integrated and complex would also believe that knowledge is changing and evolving and that knowledge derived from personal experience. In contrast, I predicted that students who view knowledge as isolated and compartmentalized would view knowledge as certain and passed down from an authority figure.

Second, students' beliefs about the structure of knowledge, stability of knowledge, and source of knowledge were hypothesized to have a direct effect on their competency beliefs, achievement value, and strategy use. To briefly explicate these relations, consider the following example. A student believes that history knowledge is changing and uncertain, this student believes that she is good at tackling more ambiguous problems. Consequently, she believes that she will do well on a history task (i.e., competency belief) and she will use strategies in this task, relying more heavily on deep-processing strategies than surface level strategies. Given this student's confidence in her competency and her strategy use, she will perform well on history task (i.e., task performance) Additionally, given this student's belief in the uncertainty of history knowledge and her belief in her ability, she is also likely to value doing well in history (i.e., achievement value). Thus, she is likely to want to participate in history-related learning tasks in the future (i.e., future intention). A similar path can be traced of the other dimensions of students' knowledge beliefs in a variety of different domains.

Third, the direct paths leading from competency beliefs and achievement values were based primarily on the Eccles and Wigfield research. That is, students' competency beliefs were believed to predict their performance and achievement values were predicted to influence students' intentions to engage in tasks in the future. Additionally, competency beliefs and achievement value were believed to be related. This was accounted for in the model by allowing their disturbances to covary. Further, based on the efficacy literature, I hypothesized that students' competency beliefs would influence their use of surface level, moderate-level, and deep-processing strategies. Finally, strategy use was believed to influence students' task performance.

Research Questions

The purpose of the current investigation was to test the proposed model using a sample of college students. I focused on college students because the proposed model appeared particularly relevant to the college experience. Additionally, epistemological beliefs have been previously identified and studied at the college level. In contrast, the Eccles and Wigfield model has primarily been examined in younger students. Thus, focusing on college students allowed me to replicate previous findings with respect to epistemological beliefs and extend the literature with regard to expectancy value theory while testing a model that was potentially important for college students' academic and career development.

Before the relations in the proposed model could be assessed empirically, it was important to determine the underlying structure of the various constructs. For example, although specific epistemological belief factors have been identified, additional replication work was needed to validate these factors. Additionally, the Eccles and Wigfield conceptualization of ability beliefs, expectancy beliefs, and achievement values had not been extensively studied in college populations. Consequently, the following research questions guided this investigation:

- What is the structure of students' domain-specific epistemological beliefs relative to the structure, stability, and source of knowledge in history and mathematics?
- Do students' ability beliefs differentiate from their expectancies for success relative to history and mathematics?
- What is the structure of students' history and mathematics achievement values?
- What is the nature of the relations between students' domain-specific epistemological beliefs, competency beliefs, achievement values, strategy use, performance, and future intentions with respect to history and mathematics?

Definitions of Terms

Epistemological beliefs are defined as students' beliefs about the nature of knowledge and knowing (Hofer & Pintrich, 1997). In this investigation, students' epistemological beliefs are conceptualized as being multidimensional and domain specific. This view implies that students possess beliefs about the different aspects of knowledge (e.g., structure, stability, and source), as well as different domains of knowledge, that are conceptually distinct. However, these beliefs are also viewed as part of an interrelated system of beliefs, and, thus, are likely to be related to one another.

In this investigation, I was specifically interested in the following aspects of students' epistemological beliefs:

- *Beliefs about the structure of knowledge* refer to students' beliefs about the organization of knowledge. For example, is knowledge simple and isolated or complex and well-integrated?
- *Beliefs about the stability of knowledge* refer to students' perceptions of certainty and permanence of knowledge. That is, is knowledge certain and unchanging with attainable truths or is knowledge more tentative and continually evolving such that truth is not absolute?
- *Beliefs about the source of knowledge* refer to students' beliefs about where knowledge is believed to originate. Specifically, does knowledge come from an authority figure or is it derived from personal experience and reason?

Ability beliefs refer to students' beliefs about their current competencies in different areas (Wigfield & Eccles, 2002). In contrast, *expectancies for success* pertain to students' beliefs about their abilities to succeed at future tasks (Wigfield & Eccles, 2000).

Achievement value refers to how tasks meet individuals' needs (e.g., Eccles et al., 1983; Wigfield & Eccles, 1992). Using the Eccles and Wigfield model (Wigfield & Eccles, 1992), there are four aspects of achievement value that work together to determine students' achievement-related choices:

- *Intrinsic value* refers to the enjoyment experienced by simply engaging in a specific task.
- *Importance* or *attainment value* relates to the personal importance placed on performing well at the task.

- *Utility value* represents the usefulness of a specific activity to future goals and desired outcomes.
- *Cost value* refers to the negative aspects of engaging in a task such as the amount of time, effort, and money a task will require as well as the lack of time for more enjoyable tasks.

Strategy use is defined as students' deliberate use of procedures meant to assist them comprehend written material, understand the presented ideas, and incorporate the information into their existing knowledge structures (e.g., Sperl, Buehl, Fives, & Chui, 2001; Weinstein & Mayer, 1986).

- *Surface-level strategies* refer to the strategies students use to comprehend the text. Such strategies include rereading portions of the text, skipping difficult sections, and underlining important information.
- *Deep-processing strategies* refer to strategies that students use to actively grapple with ideas and interact with the presented information. Questioning the presented information, elaborating on the main idea, and relating the information to personal experiences are examples of deep-processing strategies.

Task performance refers to the amount of knowledge students gain from a learning task. Conceived in this way, task performance takes prior knowledge into consideration.

Future intentions refer to choices students would make if they had the opportunity to pursue different activities.

CHAPTER II

REVIEW OF RELEVANT LITERATURE

The purpose of this review is to provide a framework for the exploration of the interrelationships among students' beliefs about knowledge and their achievement motivations. To accomplish this purpose, published works in the philosophical, psychological, and educational literatures are reviewed and presented in three major sections. The first section addresses the epistemological belief literature. Specifically, the review offers a historical perspective on the study of students' epistemological beliefs, as well as an overview of the current trends and themes in the belief literature. The second major section addresses students' achievement motivations. Given the breadth of work related to achievement motivation, this review focuses on three specific views of students' achievement motivation: academic goal orientation, self-efficacy, and expectancy-value. These views were chosen due to their prominence in the psychological and educational literatures, as well as their potential connection to students' epistemological beliefs. Finally, a third section presents the few empirical works that explore students' knowledge beliefs and motivation in relation to one another. Within each section, unresolved issues and apparent gaps in current understandings are highlighted. Further, the final section presents issues that require additional investigation.

What are Epistemological Beliefs?

This section provides an overview of the epistemological belief literature. First, the philosophical and psychological roots of the study of epistemology are offered as a way to frame the recent explorations of students' beliefs about knowledge. Second, contemporary issues in the study of students' epistemological beliefs are addressed. These include the conceptualization and measurement of students' beliefs and the relations among epistemological beliefs, learner characteristics, and cognitive learning outcomes.

A Historical Perspective

Philosophical Roots

Philosophical discussions about the nature of knowledge date back to the ancient Greeks. These discussions initiated the study of epistemology and laid the framework for how others would approach the study of knowledge for generations to come. The Platonic view of knowledge was particularly influential in shaping the field of epistemology. That is, in his dialogues *Meno* and *Theaetetus*, Plato addresses the nature of knowledge, distinguishing between *true belief* and *knowledge*. Essentially, what emerges is the view that knowledge is *justified true belief.* This definition of knowledge is based on three conditions: truth, belief, and evidence.

Specifically, the first condition of knowledge, truth, implies that there is no false knowledge. For knowledge to exist a given proposition must be true. Consequently, "knowing…has an independent factual reference" (Scheffler, 1965, p. 26). However, a truthful and accurate representation of reality alone does not constitute knowledge. The second condition of knowledge, belief, stipulates that the individual must believe that the proposition is true. Indeed, a multitude of true propositions exist, but an individual can only *know* the propositions that he or she personally accepts and internalizes. Finally, the evidence condition requires the individual to have adequate evidence to justify the belief that the proposition is true. That is, belief in the truth of a proposition must be supported by reason or data.

Philosophers have expended considerable time and energy exploring the intricacies of these conditions, particularly the truth and evidence conditions. For instance, with regard to the truth condition, questions arose as to the certainty of truth. That is, are there absolute truths? Further, if absolute truth does exist, can we ever be certain that we have that truth? The need to justify one's belief in the truthfulness of the proposition evoked discussions related to the evidence condition. These discussions focused on the standards used to judge the adequacy of evidence, as well as the need for such evidence to be organized into a coherent argument in support of the proposition.

Over the centuries, various philosophic approaches to and theories of knowledge have emerged, often holding different bodies of knowledge (e.g., mathematics or the natural sciences) as the ideal. However, each has, in some way, addressed the three conditions of knowledge posed by Plato.

A Psychological Perspective

William G. Perry (1970) is credited with being one of the first to examine students' beliefs about knowledge empirically. Indeed, his work sparked a host of studies that have contributed greatly to current understanding of students' epistemological beliefs (e.g., Schommer, 1990). However, Perry was neither a philosopher nor a cognitive psychologist. To the contrary, he was trained in English Literature and founded the Bureau of Study at Harvard College in 1947. Much of his career was spent counseling, tutoring, and teaching undergraduates at Harvard. Through these experiences, Perry developed an interest in the moral and intellectual development of college students.

During the late 1950s and early 1960s, in an effort to understand the development of college undergraduates more fully, Perry (1970) interviewed male students at Harvard as they progressed through their undergraduate education. After examining students' responses, he proposed a hierarchical scheme to organize the various perspectives students took in their approach to knowledge and learning. Specifically, Perry characterized students on the basis of their beliefs and placed them along a continuum ranging from dualism to relativism. Students with rather dualistic notions of knowledge view all information as either right or wrong and hold that knowledge comes from an authority figure. In contrast, students with more relativistic conceptualizations of knowledge question the certainty of knowledge and recognize its complex, contextual nature. Students adopting this viewpoint are also much more likely to see themselves inferring meaning from the information they encounter (Perry, 1970).

However, it is important to recognize that Perry did not explicitly study students' epistemological beliefs. Instead, he was primarily interested in understanding the experiences of college undergraduates. Consequently, he did not specifically address the facets of knowledge, although they were incorporated, to some extent, in the various perspectives he proposed. Further, Perry addressed other aspects of the undergraduate experience, such as social and extracurricular activities, and included them in his proposed scheme. Even so, Perry's conceptualization of dualistic and relativistic perspectives was influential for several reasons. First, he brought attention to the fact that college students possess evolving beliefs about knowledge. Second, he inspired multiple lines of research as others attempted to include the perspectives of women (e.g., Belenky, Clinchy, Goldberger, & Tarule, 1986) and refine Perry's proposed scheme (e.g., King & Kitchener, 1994; Schommer, 1990).

Contemporary Conceptualizations of Epistemological Beliefs

In contrast to the theoretical debates and discussions among philosophers, a new perspective on epistemology has emerged in the last 30 years. Specifically, this period has been marked by an increased interest in individuals' conceptualizations of knowledge (e.g., King & Kitchener, 1994; Perry, 1970). Further, researchers have devoted particular attention to exploring the knowledge beliefs of students in academic settings (e.g., Buehl et al., 2002; Schommer 1990). Researchers have also investigated how such beliefs relate to various learner characteristics and learning outcomes (e.g., Jehng, Johnson, & Spiro, 1993; Qian & Alvermann, 1995). Consequently, in my review of the epistemological belief literature, I will focus primarily on the epistemological beliefs of students. Although the term "students" would typically include individuals in kindergarten through graduate school, the majority of the literature has addressed the beliefs of high school and college students.

Before students' beliefs about knowledge could be explored in relation to other constructs, researchers had to establish the nature of those beliefs. In particular, early investigations focused on how individuals' epistemological beliefs developed and changed over time. Consequently, a developmental perspective is implied in much of the initial work on the nature of students' beliefs about knowledge (e.g., Baxter Magolda, 1992; King & Kitchener, 1994). Although more recent studies also investigate changes in beliefs over time (e.g., Schommer et al., 1997), investigations have focused on empirically exploring the structure and specificity of students' knowledge beliefs.

In the subsequent sub-sections, I first discuss how epistemological beliefs were initially conceptualized and studied in the literature. This is followed by a discussion of the more recent multidimensional conceptualizations of knowledge beliefs. Finally, I address the specificity of beliefs. That is, are knowledge beliefs more general constructs at work in most situations or more specific to particular bodies of knowledge?

Initial Conceptualizations

Belenky et al.'s Women's Ways of Knowing. In response to Perry's use of an all male sample, Belenky et al. (1986) interviewed adult, primarily college-educated, women and employed a phenomenological approach to determine their views of knowledge. The model of beliefs that emerged from those interviews, referred to as "women's ways of knowing," was structured around the concept of voice and how the women view themselves in relation to knowledge. Specifically, Belenky et al. proposed that women adopt one of five positions toward knowledge and knowing (i.e., silence, received knowing, subjective knowing, procedural knowing, and constructed knowing). However, the questions used to elicit women's responses were not necessarily situated in the context of academic knowledge and learning and addressed many different aspects of women's lives. Belenky et al. also did not focus solely on epistemological beliefs. Additionally, their data were primarily cross-sectional. Although their model implies change, they did not adopt a strict developmental perspective. Further, similar to Perry's work, this program of research was limited to an examination of responses from one gender.

Baxter Magolda's Epistemological Reflection Model. In contrast to Perry and Belenky et al., other researchers have studied the beliefs of both males and females (e.g., King & Kitchner, 1994). For instance, Baxter Magolda (1992) attempted to quantify the various perspectives proposed by Perry (1970) using a sample of male and female college students. Specifically, she interviewed students annually and had them respond to the

Measure of Epistemological Reflection, an open-ended questionnaire. However, students' responses did not correspond to Perry's perspectives. Consequently, Baxter Magolda developed an interest in the differences between Perry's scheme, developed on an all male sample, and Belenky et al.'s "women's ways of knowing" model. Baxter Magolda subsequently explored her students' responses and proposed her own model, the Epistemological Reflection Model, to capture students' conceptualizations of knowledge and learning. This model consisted of four different "ways of knowing:" *absolute knowing* (knowledge is certain and absolute), *transitional knowing* (knowledge is partially certain and partially uncertain), *independent knowing* (knowledge is uncertain and alternative views can be justified), and *contextual knowing* (knowledge is judged on the basis of evidence).

Although individuals were said to adopt one of four ways of knowing, there were a continuum of differences in how students justified their epistemic assumptions within each way of knowing. Further, specific gender patterns emerged. For example, students characterized as adopting an absolute way of knowing could be placed along a continuum from *receiving* (more prevalent among women) to *mastery* (more prevalent among men). Within transitional knowing, students tended to take a more *interpersonal* (common among women) or *impersonal* (common among men) approach. Independent knowing ranged from *interindividual* (more likely among women) and *individual* (more likely among men). Gender patterns appeared to converge within contextual knowing. Thus, Baxter Magolda proposed a way to classify students' beliefs into discrete categories, while also exploring the variations evident within each different way of knowing.

In many ways, Baxter Magolda's work is reflective of Perry's initial investigation. That is, Baxter Magolda's assessment of beliefs was more academically focused than that of Belenky et al. (1986). However, like Perry, she also addressed a number of beliefs that, although related to knowledge and learning, were not necessarily epistemological. For example, in her descriptions of the various ways of knowing, Baxter Magolda included beliefs about the role of peers and the instructor in the learning process and students' beliefs about evaluative procedures. The inclusion of such non-epistemological beliefs likely rests on the intentions behind her investigation. That is, similar to Perry, Baxter Magolda was primarily interested in the intellectual development of college students.

Kuhn: Epistemological reasoning in everyday life. Other researchers were motivated to explore individuals' beliefs about knowledge for different reasons. For instance, Deanna Kuhn (1991) was interested in the reasoning that occurs in everyday lives. To address this issue, she presented individuals in their teens, 20s, 40s, and 60s with three ill-structured problems (e.g., what causes unemployment). Kuhn first asked them to state and justify their position with regard to each problem. She then had the individuals generate and rebut an opposing view, offer a solution, and discuss the epistemological standards they used to formulate the solution and justification.

In her analysis of participants' responses, Kuhn identified three distinct epistemological views related to the certainty of expertise. Specifically, *absolutists* hold that knowledge is certain and absolute whereas *multiplists* are skeptical of the certainty of knowledge and hold that all views are equally valid. Finally, individuals with *evaluative* stances are also skeptical of the certainty of knowledge but, in contrast to the multiplists, they recognize that viewpoints can be compared and evaluated. These epistemological views are similar to those presented by others (e.g., Perry, 1970), but they do not include some of the extraneous non-epistemological issues addressed in the previous models. However, Kuhn was interested in everyday reasoning. Consequently, her choice of participants, as well as the problems she used to uncover individuals' beliefs, pertained to more general knowledge beliefs and did not reflect beliefs about academic knowledge.

King and Kitchener's Reflective Judgment Model. King and Kitchener (1994) took an approach similar to Kuhn's in their efforts to understand the processes used in argumentation. That is, they sampled a cross section of individuals with varied educational experiences (i.e., high school students, college undergraduates, graduate students, and non-student adults). These individuals were presented with four different ill-structured problems and asked a series of questions designed to assess their beliefs about knowledge and their justification for those beliefs. Based on participants' responses, King and Kitchener developed a seven-stage model, the Reflective Judgment Model, to describe individuals' views of knowledge and their conceptions of justification and argumentation. The stages they proposed embodied many of the ideas presented by Perry and expanded on his views related to relativism. However, the problems used to generate this model did not rely on "schooled" knowledge. Further, similar to the other researchers, King and Kitchener were not primarily interested in developing a model of epistemological beliefs. Instead, they were focused on understanding the processes used to make interpretative arguments.

Summary. In examining the work of Perry, Belenky et al., Baxter Magolda, Kuhn, and King and Kitchener, several trends are apparent. For one, there appears to be a general interest in the development of individuals' beliefs over time. Longitudinal and cross-sectional samples were employed to determine the transformations individuals experienced with age and education. Additionally, researchers used interviews and open-ended questionnaires to deeply explore individuals' views related to knowledge and learning.

However, discrepancies in the way individuals' beliefs were conceptualized and assessed are also evident. Perhaps most notably, Perry, Belenkey et al., Baxtger Magolda, Kuhn, and King and Kichener are not philosophers dedicated to the study of epistemology. Instead, they were guided by varied interests and motives (e.g., a desire to understand the development of college students or argumentative reasoning). Indeed, the emergence of individuals’ beliefs about knowledge appears to be a by-product of the researchers' primary pursuits. Consequently, the proposed models are not necessarily informed by previous philosophical writings on epistemology but are, instead, colored by each researcher's unique background and academic tradition. This leads to a somewhat fragmented and disjointed view of individuals' conceptions of knowledge.

Further, there are variations in the types of knowledge beliefs addressed in the different models. For example, Perry and Baxter Magolda's interests in the development of college students led them to explore students' beliefs in more of an academic context. However, these models also incorporated issues that were not directly related to epistemology (e.g., students' social lives or their beliefs about the role of peers). In contrast, the models proposed by Kuhn (1991) and King and Kitchener (1994) are more closely related to the study of knowledge and epistemology. However, these researchers were interested in everyday thinking. The beliefs they assessed pertain to more general knowledge, not that acquired through schooled experiences.

Finally, in each of the presented models, researchers proposed a series of qualitatively different perspectives that individuals progress through depending on their age and experiences. In effect, each perspective represents a way to characterize individuals' responses along a single continuum. Although the various aspects of knowledge may be discussed, it is assumed that these beliefs are similar and reflective of individuals' developmental level. Thus, an individual's beliefs about knowledge and learning are characterized by only one perspective or belief category. This approach is described as being *unidimensional* in that individuals are only charted along a single dimension pertaining to beliefs about knowledge. The categorizations do not acknowledge that individuals' beliefs about the various aspects of knowledge may be at different levels of sophistication. Instead, individuals' knowledge beliefs are considered to be relatively similar or *synchronous* such that it is possible to classify an individual as taking a particular stance toward knowledge.

A Multidimensional Conceptualization

Although the empirical study of knowledge beliefs may have originated with Perry and continued with the work of Belenky et al., Baxter Magolda, Kuhn, and King and Kitchener, the epistemological beliefs research has undergone significant transformations in the last decade. These changes are due, in part, to the work of Marlene Schommer-Aikins. She added to the literature by providing a new model for conceptualizing beliefs, developing a paper-and-pencil measure of beliefs, and by situating the study of epistemological beliefs within an academic context.

Specifically, Schommer-Aikins (Schommer, 1990) was interested in how students' beliefs about the nature and acquisition of knowledge influenced their approaches to learning. However, she questioned the predominantly unidimensional representations of individuals' knowledge beliefs and proposed that students' epistemological beliefs consist of several independent beliefs. That is, she suggested that epistemological beliefs are multidimensional and asynchronous. Further, Schommer-Aikins (Schommer, 1990) proposed five different epistemological dimensions related to the structure, certainty, and source of knowledge, as well as the speed and control in the acquisition of knowledge. She held that these dimensions are independent and that an individual may show varied levels of sophistication with respect to each dimension. Theoretical support for these dimensions was drawn from Perry's scheme, Dweck's (Dweck & Leggett, 1988) work on beliefs about intelligence, and Schoenfeld's (1983) work on students' beliefs about mathematics learning.

Schommer-Aikins sought to validate her proposed model empirically by developing a 63-item questionnaire, the *Schommer Epistemological Questionnaire* (SEQ). The items on this instrument were developed to tap into 12 different subsets of beliefs (e.g., "avoid ambiguity" and "knowledge is certain"), each of which related to one of the five proposed dimensions (e.g., the certainty of knowledge). In the initial investigation, the SEQ was administered to 263 first- and second-year college students and four factors emerged from an exploratory factor analysis of the data.

These factors corresponded to the four of the five dimensions that Schommer-Aikins proposed (i.e., beliefs related to the certainty or stability of knowledge, the structure or simplicity of knowledge, the speed of knowledge acquisition, and students' control in the acquisition of knowledge). In her discussion of those factors, Schommer-Aikins (Schommer, 1990) made a distinction between what she considered more *naïve* and more *sophisticated* stances with respect to each belief factor. This terminology has been used regularly by Schommer-Aikins and others (e.g., Kardash & Scholes, 1996) to define the belief continua in subsequent works. However, more recently, the value judgment implicit in referring to some beliefs as sophisticated and other beliefs as naïve has been called into question. Instead, researchers (e.g., Hammer & Elby, 2002) have suggested that the sophistication or naiveté of a belief depends on the specific context. This argument certainly has merit. However, in an effort to adequately represent previous works, I, too, will use this terminology to discuss the findings.

The naïve versus sophisticated belief issue is apparent in the way that Schommer-Aikins labeled and described her factors. She initially referred to the four emergent factors from what she considered a more naïve perspective (i.e., Simple Knowledge, Certain Knowledge, Quick Learning, and Innate Ability. In more recent works, Schommer-Aikins, Mau, Brookhart, and Hutter (2000) relabeled these factors as Structure of Knowledge, Stability of Knowledge, Speed of Learning, and Ability to Learn. Despite the different labels, the belief factors have not changed nor the assumption that some beliefs are more desirable than others. Specifically, the Structure of Knowledge (Simple Knowledge) factor addresses students' beliefs about the complexity of knowledge. Positions range from viewing knowledge as a collection of isolated facts to seeing knowledge as a series of interrelated ideas. The Stability of Knowledge (Certain Knowledge) factor addresses students' beliefs as to whether knowledge is absolutely certain or tentative and conditional. The Speed of Learning (Quick Learning) factor represents students' beliefs about the speed of knowledge acquisition. Positions on this factor range from the belief that learning should occur quickly or not at all to the belief that learning occurs gradually over time. Finally, the Ability to Learn (Innate Ability) factor reflects students' beliefs about the innateness of ability and students' control over the acquisition of knowledge. Positions range from the beliefs that ability is fixed at birth to the belief that students can be taught how to learn.

Schommer-Aikins had proposed a fifth belief dimension related to the source of knowledge. (Is knowledge handed down by an authority or developed from individuals' own reasoning and experiences?). This factor has not emerged in any of her studies. However, Schommer-Aikins and her colleagues (e.g., Schommer, 1993b; Schommer et al., 1992; Schommer et al., 1997) have found additional support for the four identified belief factors with various high school and college samples.

Concerns have been raised with regard to the dimensions proposed by Schommer-Aikins and the methods she used to substantiate their existence. For instance, with regard to the conceptualization of beliefs, Hofer and Pintrich (1997) have questioned whether beliefs about the speed of learning and the ability to learn are actually epistemological issues. Additionally, the methods used identify the factors have been called into question, along with Schommer-Aikins' interpretation of her analyses (e.g., Qian & Alvermann, 1995).

Despite the methodological criticisms of Schommer-Aikins's work, which are discussed in greater detail in the following section, the multidimensional conceptualization of knowledge beliefs has been supported by multiple programs of research. Belief factors similar to those proposed by Schommer-Aikins have been identified in multiple studies conducted using the SEQ (e.g., Kardash & Scholes, 1996). Additional dimensions of students' knowledge beliefs have also been proposed and identified by new belief measures (e.g., Hofer, 2000). Further, the proposed dimensions of beliefs are differentially related to various learner characteristics and learning outcomes (e.g., Kardash & Howell, 2000; Schommer et al., 1992). Although Schommer-Aikins' methods may be flawed, her conceptualization of beliefs revolutionized the study of epistemological beliefs.

Specificity of Beliefs

In addition to the dimensionality of epistemological beliefs, another issue to consider in the conceptualization of individuals' beliefs about knowledge is the domain-specificity or domain-generality of such beliefs. That is, do epistemological beliefs differentiate or vary by domain, or do the same basic beliefs guide individuals' actions regardless of the context? The answer to this question depends on the theoretical perspective of the researchers and the manner in which epistemological beliefs are assessed. Until recently, the majority of the epistemological belief literature could be categorized as taking one of two approaches with regard to the specificity of beliefs. In the first approach, researchers and educators explored students' views about particular areas of study in an attempt to develop students' reasoning and thinking in that content area. In the second approach, epistemological beliefs were assessed independent of a specific domain of study. More recent research suggests that epistemological beliefs are both domain-general and domain-specific.

Evidence from content area research. Researchers interested in students' reasoning and development relative to a specific content often explicitly address or inadvertently uncover students' beliefs about knowledge in their investigations. A particular case in point can be seen within the science education literature. A substantial body of work has explored students' beliefs about science and scientific knowledge (e.g., diSessa, 1993; Hammer, 1994; Roth & Roychoudhury, 1994). Using interviews and written questionnaires researchers examined students' beliefs about how knowledge is acquired and justified in science (e.g., Smith, Maclin, Houghton, & Hennessey, 2000; Songer & Linn, 1991). In these investigations, researchers have allowed students' views to emerge from their responses (e.g., Hammer, 1994) or have attempted to characterize students' beliefs based on a predetermined set of criteria (e.g., Tsai, 2000a). The insights gained from such investigations are intended to guide instructional practices and advance students' understanding of the domain of science.

However, within the science education literature, a constructivist epistemology of science is held as the ideal. That means that researchers want students to recognized that scientific knowledge evolves through a process of conjecture, argument, and experimentation that is open to interpretation and debate (e.g., Carey et al., 1989). Further, they want students to view scientific knowledge as an invented reality that is socially constructed and impacted by contextual and cultural factors (Tsai, 2000a). Thus, instead of seeking truth, students should embrace the many alternatives that may exist (Roth & Roychoudhury, 1994). Consequently, efforts have been directed at how to foster such beliefs in students (e.g., Carey et al., 1989; Smith et al., 2000).

Similar programs of research have been pursued in other content areas as well. For instance, Schoenfeld (1985) examined students' beliefs about mathematics knowledge and Wineburg (1991) focused on students’ beliefs about learning history. Such in-depth analyses of beliefs within a single domain are useful for developing rich portrayals of how students’ approach knowledge. These programs of research have also made useful recommendations for instruction. However, this work is situated within a single domain (e.g., science or history). Researchers' interpretations of their data are colored by their own epistemological stances with regard to the domain. For example, within the science education literature, a constructivist stance is assumed to be the more sophisticated position. Due to cross-domain variations in experts' conceptualizations of knowledge, it is difficult to generalize outside of a specific domain. Also, because these investigations were conducted within a single domain, judgments could not be made as to the consistencies or variations in students' beliefs about knowledge in different domains. Further, within this body of work beliefs about knowledge are often assessed, analyzed, and presented in conjunction with beliefs about the domain. Thus, this work does not represent an unconfounded assessment of students' epistemological beliefs.

A generalist approach to epistemological beliefs? In contrast to studying students' beliefs within a particular domain of study, the second approach to exploring epistemological beliefs has been to address general knowledge beliefs. That is, the questionnaires and interviews used to assess beliefs do not specify a particular body or domain of knowledge (Baxter Magolda, 1992; Qian & Alvermann, 1995; Schommer, 1990). Although, some studies have been situated in academic setting, presumably examining students' beliefs about academic knowledge (e.g., Baxter Magolda, 1992; Schommer, 1990), others (e.g., King & Kitchener, 1994; Kuhn, 1991) have examined beliefs about knowledge that did not necessarily pertain to academic settings. Moreover, the questions and measures used to assess individuals' knowledge beliefs did not indicate a specific academic domain of knowledge. Thus, as suggested by Schommer and Walker (1995), there appeared to be an implicit assumption that epistemological beliefs are independent of specific domains. Recent works examined and challenged this assumption.

For example, Schommer and Walker (1995) conducted a within-subject analysis of undergraduates' beliefs relative to mathematics and social science in an effort to determine if students' beliefs about knowledge are domain independent or domain dependent. They conducted two studies in which each student completed two modified versions of the SEQ, one pertaining to mathematics and one pertaining to social science. The four-factor belief model identified in previous investigations with the SEQ was applied to the data, and students' beliefs about knowledge in mathematics and social science were forced onto the same factor structure.

Several techniques were used to analyze the data and test the domain-independence assumption. In the first investigation, Schommer and Walker used regression to determine that the four mathematics belief factors significantly predicted the four social science belief factors, explaining between 31% and 50% of the variance. The consistency of students' beliefs about mathematics and social science knowledge was also examined. Specifically, using median-split procedures, Schommer and Walker classified students' as holding consistent or inconsistent views across mathematics and social science for each of the four belief factors and found a consistency rate of 68% to 79%.

In the second investigation, the SEQ was modified to ensure that students considered the appropriate domain as they responded to the items. In effect, the target domain was inserted into every third item. Further, students read either a statistics or psychology passage and completed a comprehension test. The results of regression analyses were similar to those in the first study (i.e., the mathematics beliefs factors significantly predicted the social science belief factors) and students tended to demonstrate consistency in their beliefs as assessed by the four factors (i.e., consistency rate of 57% to 70%). Additionally, the assessed beliefs significantly predicted reading comprehension irrespective of domain. That is, students' performance on the psychology comprehension test was significantly predicted by their belief in the certainty of mathematics knowledge and their belief in the certainty of social science knowledge. Performance on the mathematics comprehension test was significantly predicted by students' beliefs in the simplicity of knowledge in mathematics or social science. Based on these findings, Schommer and Walker (1995) concluded that epistemological beliefs are moderately domain-independent.

A call for domain-specific epistemological beliefs. However, the evidence of the domain-independence of epistemological beliefs appears inconsistent with the literature on domain knowledge. That is, academic domains are presumed to differ in structure and content (Frederiksen, 1984; Spiro & Jeng, 1990; Stewart, 1987; Wineburg, 1996). Studies employing between-subject designs also suggest domain differences. For instance, Jehng et al. (1993) and Paulsen and Wells (1998) found that college students majoring in “soft” fields (e.g., social sciences and education) held different beliefs about knowledge than students majoring in “hard” fields (e.g., natural sciences and engineering). Lonka and Lindbloom-Ylänne (1996) also found that medical students tend to be more dualistic in their views of knowledge whereas psychology students are more relativistic.

Others (e.g., Buehl et al, 2002; Hofer, 2000) have explored the potential of domain-specific beliefs about knowledge. Such investigations employed within-subject analyses. For example, Stodolsky, Salk and Glaessner (1991) interviewed fifth grade students with regard to their attitudes, perceptions, and dispositions towards mathematics and social studies. A content analysis of students' responses revealed differences in the source and acquisition of knowledge within each domain as well as differences in the definitions of each domain. However, this study did not directly address students' epistemological beliefs. Further, apparent differences may have been due to lack of clarity with regard to social studies.

More recently, within-subject analyses with older populations have specifically addressed some of the methodological confounds in the Schommer and Walker study (Buehl et al., 2002; Hofer, 2000). For example, Schommer and Walker used the SEQ, a measure of students' general knowledge beliefs, to assess beliefs relative to specific domains of study. There were several problems in the use of this instrument to explore the possibility of domain-specific beliefs. For example, although Schommer and Walker modified the domain-general SEQ to assess domain-specific beliefs, the target domains they selected (i.e., mathematics and social science) were broad, encompassing many areas of study that varied in structure and content. Additionally, the individual items on the SEQ did not refer to the target domain, raising concerns as to what areas of study students considered as they completed the instruments. Schommer and Walker attempted to rectify this problem in their second study by inserting the target domain into every third item. However, the validity of such changes is questionable. Several of the SEQ items do not apply to academic knowledge, let alone knowledge in a specific domain (e.g., "Self-help books are not much help" and "I don't like movies that don't have an ending").

In response to the aforementioned confounds, Hofer (2000) and my colleagues and I (Buehl et al., 2002) developed domain-specific belief questionnaires. These measures were developed with the intention of assessing beliefs about knowledge in specific areas of academic study. Fields comparable in breadth and scope were selected and the individual items specifically referred to these fields. However, there were differences in the methods used to develop and assess these measures.

Specifically, Hofer developed an instrument, the *Discipline-Focused Epistemological Beliefs Questionnaire* (DEBQ), to assess the four belief dimensions proposed by Hofer and Pintrich (1997). With regard to assessing domain-specific beliefs, the measure was administered to first-year college students twice, once with science as the area of study, and once with psychology. Exploratory factor analyses were conducted separately for science and psychology and virtually identical factors emerged for the two content areas. Additionally, comparisons by domain for the four factors revealed that students' beliefs about knowledge in science and psychology were significantly different.

In contrast, my colleagues and I initially framed our domain-specific instrument to address the factors identified by Schommer-Aikins (Schommer, 1990). A preliminary measure containing items related to mathematics and history was administered to college undergraduates. When students' responses were factor analyzed, the items loaded by domain and did not reflect the factors identified by Schommer-Aikins (Schommer, 1990). However, there was evidence of additional factors within each domain that did not emerge due to our relatively small sample size (n=181). Subsequently, the instrument, the *Domain-Specific Belief Questionnaire* (DSBQ), was revised and administered to a larger sample of undergraduates (n=623). Confirmatory factor analysis was used to assess several different models of students' beliefs. The four-factor domain-specific model (i.e., two separate factors within each domain) provided the best fit of the data. Further, this model was validated with data from an additional sample of students from the similar population. We also identified differences in students' beliefs relative to mathematics and history.

The Hofer (1999) and Buehl et al. (2002) studies offer different forms of empirical support for the domain-specificity of students' epistemological beliefs. That is, Hofer's measure was developed to assess beliefs about academic knowledge within a particular area of study, and to allow for belief comparisons across content areas. To this end, Hofer separately assessed and analyzed students' beliefs about science and psychology. The identical factor structure for both science and psychology supports the validity of the emergent factors and partially supports the belief dimensions proposed by Hofer and Pintrich (1997). However, because of Hofer's design, it is not possible to determine if the science and psychology items would have loaded on the same factors. Such a finding would refute the existence of domain-specific beliefs.

In comparison, my colleagues and I (Buehl et al., 2002) assessed students' beliefs about knowledge related to mathematics and history in the same measure and included all responses in the various analyses. Although there was the opportunity for mathematics and history items to load on the same factor, this did not occur, thereby addressing a possible criticism of Hofer's work. Further, both Hofer and Buehl et al. found domain differences with respect to the specific belief factors. Consequently, this work suggests that students do hold domain-specific beliefs about knowledge.

An additional approach to the study of the specificity of individuals' epistemological understandings is evidenced in the work of Kuhn. As previously discussed, Kuhn (1991) proposed that individuals adopt an absolutist, multiplist, or evaluativist stance toward knowledge. In her more recent work, Kuhn has posited that development of such views may vary across different judgment domains (Kuhn, Cheney, & Weinstock, 2000). She distinguishes among the judgment domains of personal taste (what one finds pleasing), aesthetic (what one finds beautiful), value (what is morally appropriate), truths about the social world, and truths about the physical world. Using a cross-sectional sample of elementary-school, middle-school, high-school, and college students as well as adults with varied levels of education, Kuhn and her colleagues (2000) assessed individuals' beliefs relative to each of these judgment domains. Evidence suggested that individuals' beliefs about knowledge varied across the different judgment domains.

Although Kuhn's findings offer support to the specificity of individuals' beliefs about knowledge, there are several differences between her work and the work of Hofer and Buehl et al. First, Kuhn and her colleagues employed more of a unidimensional approach to the conceptualization of individuals' beliefs. Individuals were classified along a single continuum from absolutist to evaluativist for each judgment domain. In contrast, Hofer and Buehl et al. explored students' beliefs about knowledge with respect to several different dimensions of beliefs. Second, there are differences with regard to the type of knowledge being assessed. Kuhn's work pertains more to general knowledge beliefs whereas Hofer and Buehl et al. focus primarily on beliefs about knowledge in specific academic domains.

Despite these differences, the work of Hofer, Buehl et al., and Kuhn et al. provides evidence for the specificity of individuals' knowledge beliefs. Further, these works support the characterization of epistemological beliefs forwarded by Alexander and myself (Buehl & Alexander, 2001). Specifically, in response to the various ways epistemological beliefs have been discussed and assessed in the literature as well as our own views of knowledge, we proposed that epistemological beliefs, like knowledge itself, are multidimensional and multilayered. Just as there are different levels of knowledge (e.g., general knowledge and academic knowledge), there are different levels of epistemological beliefs that correspond to such knowledge. Consequently, individuals hold various beliefs about knowledge. Although these beliefs are certainly interrelated, the beliefs that guide individuals' actions will depend upon the specific context. The Hofer and Buehl et al. studies offer examples of students' domain-specific academic knowledge beliefs while Kuhn et al.'s work provides evidence of the specificity of more general knowledge beliefs. The emergence of such varied, yet related, forms of knowledge beliefs is likely related to the measures and questions used to unearth individuals' epistemologies.

Summary of the Conceptualization of Epistemological Beliefs in the Current Literature

A review of the current epistemological belief literature reveals several significant developments in the conceptualization and study of epistemological beliefs since Perry's initial empirical work. First, the conceptualization of epistemological beliefs has expanded to include the views of female as well as male students (e.g., Baxter Magolda, 1992). Second, epistemological beliefs are now more fully situated in academic and non-academic contexts. For example, Baxter Magolda (1992) and Schommer-Aikins

(Schommer, 1990) explored the beliefs of college students whereas Kuhn (1991) and King and Kitchener (1994) did not specifically refer to academic knowledge in their investigations of students and adults in non-academic settings. Third, Schommer-Aikins (Schommer, 1990) proposed that students' beliefs about knowledge may actually be a system of independent beliefs. These beliefs vary with regard to their development and sophistication *within* the individuals (i.e., an asynchronous and multidimensional view of epistemological beliefs). Finally, the research suggests that although students may possess more general beliefs about knowledge, epistemological beliefs can also be domain specific.

Measurement of Epistemological Beliefs

As discussed in the previous section, the measurement of epistemological beliefs is a key issue in the study of individuals' knowledge beliefs. Indeed, the emergence of a construct, as well as its relationship to other relevant constructs, rests largely on the way that it is assessed. In this section, I specifically explore the measures and techniques used to assess epistemological beliefs. As I examined the extant literature, it became apparent that epistemological beliefs have been assessed using various measures and techniques. This variety in assessment measures and techniques is evident in Table 1 (Appendix A).

Summarizing the Measurement of Epistemological Beliefs

Specifically, Table 1 (Appendix A) presents the author or authors of specific measures or data sources. Assessments were included in the table if they were presented in a published work, represented a unique means of assessing individuals' beliefs about knowledge, and adequate information was provided as to the specific questions or items that were employed such that the assessment could be replicated. Further, attempts were made to be exhaustive as possible in the identification of various belief assessments.

For each entry in the table, I cited either the first published work in which the measure was introduced or what would be considered a seminal piece that provides a full description of the specific measure. When possible, I use the title developed by the authors or the title adopted by other researchers. For example, Jehng et al. (1993) developed a measure of beliefs using items from the SEQ and an unpublished measure developed by Spiro (1989). Although they do not name the measure other than to say that it is an epistemological belief instrument, several others (e.g., Cole, Goetz, & Willson, 2000; Youn, 2000) have used the measure in their research and referred to it as *Jehng's Epistemological Questionnaire*. I refer to the measure by Jehng et al. in the same way. If a name was not available for a specific assessment, I simply indicate the technique used to obtain the data (e.g., interview or questionnaire). Additionally within the table, I present the type of questions the researchers employed, the specific beliefs they intended to assess, the sampled participants, how the data were analyzed, and a brief description of the outcome of the data analyses. With respect to the participants, unless otherwise indicated, the samples include males and females from Western countries.

Based on this information I classified the measures in various ways. First, a major distinction in the assessment of beliefs was whether the researchers took a unidimensional and synchronous approach to the conceptualization of beliefs, or if they employed a multidimensional and asynchronous approach. I subsequently created two major groupings within the table. Second, the various measures often were linked to specific programs of research. Thus, instead of presenting the assessments chronologically, I organized them according to specific lines or areas of research. Finally, given the discussion about the specificity of epistemological beliefs, I indicated the level at which beliefs were assessed. That is, I classified each measure as assessing general knowledge beliefs, academic knowledge beliefs, and/or domain-specific knowledge beliefs. This determination was based on the types of questions asked in the assessment.

I first categorized each measure as assessing beliefs about general or academic knowledge. If the questions or items referred to a school environment or schooled knowledge (e.g., "How much a person gets out of school mostly depends on the quality of the teacher;" Jehng et al., 1993), I viewed the measure as assessing Academic Knowledge Beliefs. If questions or items did not reference an academic setting (e.g., "What is true today will be true tomorrow;" Schraw, Dunkle, & Bendixen, 1995) or if the researchers were specifically addressing everyday reasoning and knowledge in non-academic environments (e.g., King & Kitchener, 1994), I viewed the measure as assessing General Knowledge Beliefs. Some measures included both types of questions and were classified as assessing both General and Academic Knowledge beliefs. Additionally, measures that addressed specific academic (e.g., Hofer, 2000) or judgment domains (Kuhn et al., 2000) were labeled as assessing Domain-Specific Knowledge Beliefs with the domain or domains assessed indicated in parentheses. In this way, multiple combinations were possible with respect to the level of beliefs assessed in a particular measure.

From the categorized data in Table 1, several trends in the measurement of epistemological beliefs became apparent. Many of these trends either apply across the various categories and groupings of measures created or they present interesting points of comparisons between the more unidimensional and multidimensional approaches to beliefs assessment.

Types of questions and items. There is some variability in the types of questions and items used to assess students' knowledge beliefs. Within the various research lines that have taken a more unidimensional approach to the study of knowledge beliefs, researchers initially tended to rely more on open-ended questions and semi-structured interviews (e.g., Baxter Magolda, 1992; Kuhn, 1991; Perry, 1970). Indeed, such techniques allowed researchers to more fully explore individuals' belief systems and propose various epistemological stages and perspectives. Once an initial belief framework had been proposed within each program of research, attempts were often made to develop measures that were less time consuming to administer and presumably more objective and easier to score. For example, several measures were developed to assess the ways of knowing that Belenky et al. (1986) identified in their interviews (e.g., Buczynski, 1993; Knight, Elfenbein, & Messina, 1995). However, most of these measures did not adequately provide the desired information and they are rarely used in the literature. For instance, Baxter Magolda (1992) developed a written version of the interview she conducted with students but, without the interviewers' probes students often gave vague responses that were difficult to score.

In contrast, multidimensional assessments of beliefs relied almost exclusively on more objectively scored, Likert scale items (e.g., Schommer, 1990; Schraw et al., 1995). This is likely due to the statistical methods used to identify the proposed dimensions. Also, when Schommer-Aikins proposed her multidimensional model of beliefs, she was able to draw on the previous research, decreasing the need for more exploratory interview techniques.

Types of beliefs. Second, there are additional differences between the unidimensional and multidimensional approaches to belief measurement in terms of the beliefs researchers intended to assess. For instance, there is greater variation with regard to the beliefs assessed by more unidimensional approaches. Knowledge beliefs are often assessed, analyzed, and presented in conjunction with beliefs that are not solely epistemological in nature. Such variations are likely due to how the empirical study of epistemological beliefs developed. That is, in many of the initial studies, researchers were interested in broader topics (e.g., argumentation or intellectual development; Kuhn, 1991; Perry, 1970) that happened to incorporate individuals' beliefs about knowledge. By comparison, the more recent multidimensional assessments targeted more specific knowledge beliefs. However, even though these measures were more directed with respect to the types of beliefs they intended to address, a variety of belief factors emerged. This issue is addressed in the following sub-section in greater detail.

Participants. The population of participants sampled is a third point of comparison across the various belief assessments. In some of the early assessments, particularly those of Perry (1970) and Belenky et al. (1986), a single gender was sampled and studied. This is likely due to the zeitgeist of the times, as well as the available population of students (e.g., Tsai, 1998a). Most assessments are now applied to more gender inclusive samples. However, these samples have been predominantly from the United States, raising concerns as to the validity of the assessments in other cultures. With regard to the age of the sampled participants, the majority of the measures were developed to assess the beliefs of college students. The few measures developed to assess the beliefs of high school, middle school, or elementary students are often related to science education. These variations are likely due to differences in the research interests and objectives.

Data analyses. Next, I examined the techniques used to analyze the data from each measure. Not surprisingly, analysis of the data was related to the types of questions and the beliefs the researchers targeted. For the interviews with more open-ended responses, researchers initially examined the data for emergent themes and used this information to propose various epistemological stages and perspectives (e.g., Belenky et al., 1986; Baxter Magolda, 1992). Standardized protocols were then developed to classify students' responses in future assessments (e.g., Boyes & Chandler, 1992; King & Kitchener, 1994). For measures with Likert scale items, factor analytic techniques were typically employed (e.g., Buehl et al., 2002; Jehng et al., 1993). However, there are some case in which researchers simply examined the internal consistency of the items they administered and subsequently dropped items to improve the overall reliability of the scale (e.g., Elder, 2002; Jacobson & Spiro, 1995).

Outcomes and specificity of beliefs. The outcomes of each assessment are similarly reflected in the beliefs researchers intended to address as well as the form of analysis they employed. It is interesting to examine the level of specificity at which beliefs were assessed in each measure. As seen in Table 1, there were relatively similar numbers of measures that separately assessed general knowledge beliefs and academic knowledge beliefs. Additionally, an approximately equal number of measures assessed both academic and general knowledge beliefs. Further, several measures are domain-specific, largely due to the various assessments that have emerged within the science education literature.

Based on this overview of how epistemological beliefs are assessed, it is apparent that there are differences in how beliefs are initially conceptualized and further defined by the various characteristics previously described (e.g., type of questions and form of analysis). Consequently, the choice of which measure to use should depend on a researcher's own theoretical perspective as well as the objectives of the research project (Duell & Schommer, 2001).

The Assessment of Multidimensional Epistemological Beliefs

Given the prominence of the multidimensional conceptualization in the literature, I chose to focus more closely on the multiple dimensions of students' knowledge beliefs (see Table 2, Appendix B). As seen in Table 1, most of the multidimensional measures of knowledge beliefs were developed based on the SEQ and the SEQ has been used by other researchers in multiple investigations (e.g., Clareabout & Elen, 2001; Kardash & Howell, 2000; Kardash & Scholes, 1996; Qian & Alvermann, 1995).

Despite its widespread use, the SEQ has received considerable criticism with respect to the methods Schommer-Aikins used to develop the instrument and analyze the resulting data. Specifically, Schommer-Aikins (Schommer, 1990) organized the 63 items of the SEQ into 12 conceptually derived subsets. She then factor analyzed composite scores from the 12 subsets, not the data from the individual items. Such analytical procedures were used in many of Schommer-Aikins' investigations with the SEQ. However, when other researchers used the SEQ and submitted the item subsets or the individual items to exploratory factor analyses, the same factors did not emerge (e.g., Mori, 1999; Kardash & Howell, 2000; Qian & Alvermann, 1995). Instead, there were often variations with regard to the number of identified factors and the nature of the beliefs the factors were meant to represent. Further, additional knowledge dimensions have also been proposed and new measures of multidimensional epistemological beliefs have been developed (e.g., Hofer, 2000; Jehng et al., 1993). Within the literature, a variety of belief factors have been identified and discussed. Some of these variations are to be expected due to the sampled populations, as well as the specific measures and forms of analyses employed. To organize this information and identify possible patterns, I created Table 2 (Appendix B) documenting the various dimensions of beliefs that have been identified.

Investigations were included in Table 2 (Appendix B) if the identified belief factors were different from those in previous studies, if the individuals assessed were from a population that had not previously been studied, or if a new measure was used to assess students' beliefs. The studies are presented chronologically. Further, only the first published work that fit those criteria was included in the table. For example, Schommer-Aikins conducted separate studies examining the beliefs of college (Schommer, 1990), high school (Schommer et al, 1997), and middle school (Schommer-Aikins et al., 2000) students. Although the belief factors were similar for the college and high-school students, both studies were included because the multidimensional beliefs of high-school students had not previously been studied. The Schommer-Aikins et al. (2000) study was included because the instrument was administered to a new population (i.e., middle-school students) and the emergent belief factors differed from the four factors found in previous studies. Schraw et al. (1995) identified five factors similar to those originally proposed by Schommer-Aikins (Schommer, 1990). However, they employed a new measure that they developed, the *Epistemic Belief Inventory* (EBI) first described in 1995. Thus, the Schraw et al. (1995) study is included in the table, but not a later chapter detailing the development of the instrument (Schraw, Bendixen, & Dunkle, 2002).

Within Table 2, I provide information with regard to the author(s), measure, participants, type of analyses employed, and the resulting factors. For each unique factor, I also included the authors' description of each belief factor and a sample item. An examination of the information presented in Table 2 offers various explanations for the similarities and differences in the identified belief factors within the literature.

Measures. The SEQ, or a modified version of the instrument (e.g., Kardash & Howell, 2000; Mori, 1999), was used in multiple investigations. Although there are some consistencies in the factors that emerge, there is also some variation. These differences are due in part to modifications made to the measure or the type of analyses employed. For example, Mori (1999) conducted the exploratory factor analysis of the SEQ at the item level and found evidence of a five-factor solution.

In those studies that did not use the SEQ, the alternative measure was often related to the SEQ and Schommer-Aikins' conceptualization of beliefs. For instance, Jehng et al. (1993) added items to the SEQ to represent an additional aspect of knowledge (i.e., beliefs about the regularity of the learning process) and eliminated items related to Schommer-Aikins' Simple Knowledge factor. Using confirmatory factor analysis, Jehng et al. found evidence of a five-factor belief structure. Three of the five factors they identified were similar to those identified by Schommer-Aikins.

Schraw et al. (1995) developed the *Epistemic Belief Inventory* (EBI) in an effort to assess the omniscient authority factor that Schommer-Aikins proposed. Additionally, several of the items on the SEQ tended to load similarly on two factors (see Schommer, 1990, 1993b; Schommer et al., 1992) and Schraw et al. (1995) wanted to develop a measure of epistemological beliefs with clear factor loadings. The five factors identified with the EBI mirrored those proposed by Schommer-Aikins. Recent comparison of the SEQ and the EBI indicated that the EBI yielded a more consistent factor structure, was a better predictor of reading comprehension, and had better test-retest reliability than the SEQ (Schraw et al., 2002).

My colleagues and I (Buehl et al., 2002) also developed a measure of students' knowledge beliefs that was influenced by the SEQ. Specifically, we wanted to develop a measure of students' domain-specific knowledge beliefs. Although the SEQ was used as the framework for developing items, the expected structure did not emerge. Instead evidence was found for factors related to the integration of knowledge and the need for effort to acquire new knowledge.

In contrast, to Jehng et al. (1993), Schraw et al. (1995) and Buehl et al. (2002), the measure developed by Hofer (1999) was not derived from the SEQ. Specifically, in their review, Hofer and Pintrich (1997) identified a number of issues with regard to the extant epistemological belief literature. The definition of epistemological beliefs as a construct and the lack of conceptual clarity regarding various belief dimensions were two of their primary concerns. For example, Hofer and Pintrich (1997) claimed that two of Schommer-Aikins' factors (i.e., Innate Ability and Quick Learning) pertained more to beliefs about the nature of learning and intelligence than beliefs about knowledge. Hofer and Pintrich subsequently proposed that epistemological beliefs be limited to individuals' beliefs about knowledge and beliefs about knowing. The authors posited four dimensions that were encompassed by those beliefs (i.e., certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowledge). Hofer (1999) developed a questionnaire to assess the aforementioned belief dimensions and found evidence of four belief factors.

Some of the similarities among the identified belief factors thus can be attributed to overlap among the measures, particularly those derived based on the SEQ. However, some of the differences in the belief factors are likely due to the development of new measures (e.g., Schraw et al., 1995) and new belief frameworks (Hofer, 2000).

Participants. As previously discussed, measures of epistemological beliefs have typically been developed for and administered to college students. This is particularly true of multidimensional assessments of knowledge beliefs. However, a few studies have examined the beliefs of high school and middle school students. In these instances, the differences in the emergent belief structures may be due to developmental changes within individuals. For example, when Schommer-Aikins et al. (2000) administered the SEQ to seventh and eighth grade students, a three-factor belief structure emerged. Qian and Alvermann (1995) also identified a three-factor solution in their work with high school students. One possible explanation is that students' knowledge beliefs become more differentiated with age. However, this explanation does not account for why a four-factor belief solution has been found in some high school student samples and not others (e.g., Schommer, 1993b).

Most of the measures I identified were developed based on student samples from the United States or other Western countries. Recently these measures have been used to assess the beliefs of students in Hong Kong (Chan & Elliott, 2002) and Korea (Youn, 2000; Youn, Yang, & Choi, 2001). In these cases, the identified factor structure was often different from what would be anticipated based on previous research. For instance, Chan and Elliot (2002) administered a modified version of the SEQ to teacher education students from Hong Kong and identified four factors that were somewhat different from those identified by Schommer-Aikins. Youn (2000; Youn et al., 2001) identified a two-factor belief structure in his work with Korean high school and college students instead of the five factor-solution that was anticipated. Such differences may be attributable to cultural variations with regard to education and the student-teacher relationship (Youn, 2000).

<u>Analyses.</u> The type of analyses researchers use to examine the structure of students' beliefs is a third factor that may contribute to the number and nature of the identified belief factors. Out of the 17 studies I identified and included in the table, 10 employed exploratory factor analytic techniques. Four investigations used a combination of exploratory and confirmatory procedures (i.e., Buehl et al., 2002; Chan & Elliott, 2002; Schommer, 1993b; Youn, 2000). In these cases, confirmatory techniques were typically used to assess alternative factor structures identified through exploratory techniques. Three studies relied on only confirmatory factor analysis (i.e., Cole et al., 2000; Jehng et al., 1993; Schommer-Aikins et al., 2000).

Of the 14 investigations that employed exploratory factor analysis, 5 were conducted on the subset composite scores whereas seven studies submitted the individual items to the factor analytic procedures. For two investigations it was not clear if subset scores or individual items were analyzed. Further, principal axis factoring was typically used with some form of rotation. Although varimax rotation was used most frequently, oblique rotation procedures were also used with some regularity. Given variations with respect to the specific measures and samples employed in each investigation it is difficult to discern patterns with respect to the different analytical procedures and the nature of the emergent factors. However, the choices researchers made in the analysis of their beliefs likely impacted the emergence of specific belief factors.

Due to the various belief factors that emerged from relatively similar measures, I looked for the commonalities across the different factors. First, I examined how each factor was described as well as the items from each factor. Second, I formed groups that appeared to represent the general issue addressed by the factor. For example, the factors Quick Learning (e.g., Schommer, 1990), Orderly Processes (Jehng et al., 1993) Effort Pays (Clareabout & Elen, 2001), Need for Effort in the Acquisition of Knowledge (Buehl et al., 2002), and Knowledge Construction and Modification (Wood & Kardash, 2002) addressed beliefs about the acquisition of knowledge. In contrast, the belief factors Omniscient Authority (e.g., Schraw et al., 1995), Depend on Authority (e.g., Kardash & Scholes, 1996), Justification for Knowing: Personal (Hofer, 2000), Source of Knowledge: Authority (Hofer, 2000), and Authority/Expert Knowledge (Chan & Elliot, 2002) pertain to beliefs about the source of knowledge. Five general categories of belief factors were identified:

- Beliefs about the Structure of Knowledge (i.e., is knowledge simple or complex, isolated or integrated?)
- Beliefs about the Stability of Knowledge (i.e., is knowledge certain or tentative?)
- Beliefs about the Sources of Knowledge (i.e., does knowledge originate from an external source or personal experience?)
- Beliefs about the Nature of Knowledge Acquisition (i.e., is knowledge acquired quickly or gradually; is the process easy or effortful?)
- Beliefs about the Ability to Acquire Knowledge (i.e., is the ability to learn fixed or developed over time?)

The last category identified, Beliefs about the Ability to Acquire Knowledge, is primarily defined by the Innate Ability/Fixed Ability factors that emerged from the SEQ and its derivatives. Further, this category of beliefs is probably the least related to the study of epistemology, pertaining more to individuals' beliefs about intelligence (Pintrich, 2002).

Additionally, the belief factors identified in the literature do not necessarily fit precisely into one of the aforementioned belief categories. For instance, in several studies (e.g., Hofer, 2000; Qian & Alvermann, 1995), items related to the beliefs about the structure (i.e., simplicity) and stability (i.e., certainty) of knowledge loaded on the same factor. This suggests that individuals do not differentiate between these beliefs or that current measures do not adequately differentiate between these beliefs. Perhaps, as suggested by the two-factor solutions identified in some studies (e.g., Cole et al., 2000), students simply hold broader beliefs about the nature of knowledge and the nature of learning. Schommer-Aikins (Schommer, 1994) has also discussed this distinction between her proposed dimensions. That is, beliefs about the certainty, simplicity, and source of knowledge are aspects of students' knowledge beliefs while beliefs about the speed of knowledge acquisition and students' ability to learn are representative of beliefs about learning.

Epistemological Beliefs in Context

Epistemological beliefs do not develop and operate in isolation. They are merely one aspect of the learner's belief system and self schema. Thus, in order to understand epistemological beliefs more fully, it is important to situate them in a broader context.

Indeed, multiple studies have examined students' knowledge beliefs in relation to other variables and constructs. In synthesizing the results of these investigations, I identified three major themes that run though much of this work. First, epistemological beliefs have been examined in relation to specific learner characteristics (e.g., educational level and intelligence). Although much of this research is based on correlations and group comparisons, it appears that researchers are trying to understand the sources or factors contributing to variations in students' knowledge beliefs. Second, in a few studies, the malleability of epistemological beliefs has been explored. That is, investigations have examined how specific environments or forms of instruction impact epistemological beliefs. Third, and perhaps of greatest interest to educators, epistemological beliefs have been related to various learning outcomes. The implication in much of this work is that epistemological beliefs function as filters or lenses that color the way students process incoming information and guide subsequent actions. I present findings related to each of these themes.

Epistemological Beliefs and Learner Characteristics

Beginning with the work of Perry, there has been an interest in how students' knowledge beliefs are related to learner characteristics. Although some of these variables are inherent in the learner (e.g., gender), others are more environmental (e.g., culture and home environment). Further, in some cases it is difficult to untangle the internal processes (e.g., physical maturation) from external factors (e.g., education) or problems with the measurement of beliefs.

Age and education. Many of the early investigations of students' epistemological beliefs focused on how beliefs changed and developed over time. However, it is difficult to differentiate the internal processes of physical and cognitive maturation from educational experiences that students encounter as they mature and develop. In one investigation, Schommer-Aikins (Schommer, 1998) addressed this issue by alternatively controlling for age and education. She found that after controlling for education, age was a significant predictor of changes in individuals' beliefs about learning (i.e., beliefs about the speed of learning and students' ability to learn). In contrast, after controlling for age, education was a significant predictor of the sophistication of knowledge beliefs (i.e., beliefs about the certainty and simplicity of knowledge). Thus, she concluded that age and education differentially impact students' beliefs. However, few others have made such distinctions in their work. Consequently, I have chosen to discuss students' knowledge beliefs in light of age and education.

In his initial work, Perry (1970) found that as students progressed through college their views shifted from being more dualistic to being more relativistic. Cross-sectional studies by King and Kitchener (1994) and Kuhn (1991) also suggest that there are changes in individuals' positions along the respective continua associated with age and education. Although King and Kitchener (1994) included adolescents in some of their studies, much of the early work has focused primarily on college students and adults, a relatively limited age and education bracket.

In contrast, more extensive developmental differences have been explored in studies adopting more multidimensional conceptualizations of beliefs. First, variations have been noted with regard to the structure of students' beliefs. For instance, multiple studies with college students have provided support for a four-factor or five-factor belief structure (e.g., Jehng et al., 1993; Kardash & Howell, 2000; Schraw et al., 1995), identifying factors related to the certainty or stability of knowledge, the structure or simplicity of knowledge, the source of knowledge, the speed of knowledge acquisition, and students' ability to learn. However, when similar measures (e.g., SEQ) were used with middle-school and high-school students a three-factor solution emerged (Qian & Alvermann, 1995; Schommer-Aikins et al., 2000).

Specifically, in their work with seventh- and eighth-grade students, Schommer-Aikins and her colleagues (2000) identified belief factors related to the stability or certainty of knowledge, the speed of learning, and students' ability to learn but not beliefs about the structure of knowledge (i.e., a Simple Knowledge factor). Qian and Alvermann (1995) examined the beliefs of high-school students and found that items related to the certainty and the simplicity of knowledge loaded on the same factor. These finding suggests that perhaps younger students do not hold distinct beliefs about these aspects on knowledge. Instead, beliefs about the certainty and simplicity of knowledge may emerge and become more differentiated with age and education.

The results of other investigations appear, at first glance, to contradict the differentiation of beliefs over time and raise doubts as to whether beliefs about the certainty and simplicity of knowledge truly represent distinct dimensions of beliefs at any age (Hofer, 2000; Schommer, 1993b). For instance, when Schommer-Aikins (Schommer, 1993b) examined the knowledge beliefs of high-school students, she claimed to identify a four-factor belief solution in which beliefs about the certainty and simplicity of knowledge were differentiated. However, a close examination of the factor structure reported by Schommer-Aikins (Schommer, 1993b) in her investigation of high-school students reveals that the Certain Knowledge factor is only defined by one subset score (i.e., "knowledge is certain'). A second subset score that was hypothesized to load on the Certain Knowledge factor (i.e., "avoid ambiguity") loaded on the Simple Knowledge factor. Consequently, students' beliefs may not be as well differentiated as Schommer-Aikins implied. Additionally, this analysis was conducted on a sample of freshman, sophomores, juniors, and seniors. Therefore, differences in the structure of beliefs that may emerge throughout the course of high school would have been masked.

In another study with college students, Hofer (2000) hypothesized that items related to the certainty and simplicity of knowledge would load on different factors, but only a single factor related to the certainty and simplicity of knowledge emerged. One explanation for this could be that Hofer analyzed the individual items, as opposed to subset scores. However, it is also notable that she sampled college freshmen while studies that identified distinct beliefs about the certainty and simplicity of knowledge included students who were farther along in their college education (e.g., Schraw, et al., 2002; Schraw, et al., 1995).

Although these findings underscore the methodological issues that plague the epistemological literature, they also suggest that, perhaps, students' knowledge beliefs become more differentiated with age and education. There is also evidence that knowledge beliefs become more sophisticated with age and education. For example, in a longitudinal study of high- school students, Schommer-Aikins and her colleagues (1997) found that students believe less in the certainty and simplicity of knowledge, the innateness of ability, and rapid acquisition of knowledge as they progress through four years of high-school. That is, in a longitudinal study of high-school students, Schommer-Aikins and her colleagues (1997) found that students' beliefs became more sophisticated as they progressed from their first year of high school to their senior year of high school. Although some could argue that these changes are simply a function of age, a comparison of gifted and non-gifted students suggest that educational experiences may play a role as well. Specifically, while lower division students (i.e., freshman and sophomores) held relatively similar beliefs about knowledge, there were significant differences between the epistemological beliefs of upperdivision (i.e., juniors and seniors) gifted and non-gifted high school students (Schommer & Dunnell, 1994). The varied educational experiences available to gifted students is one explanation for this apparent difference in beliefs about knowledge.

Evidence also suggests that students' knowledge beliefs continue to develop after high school. For instance, beliefs about the simplicity of knowledge were negatively correlated with number and level of college level language courses (Mori, 1999). That is, students who took more language courses and/or more advanced courses were less likely to believe that knowledge is simple. Schommer-Aikins (Schommer, 1993a) found differences between the beliefs of students attending a junior college (i.e., community college) and students attending a state university. Even after statistically controlling for parents' education level and students' home environment, junior college students tended to believe more in the certainty of knowledge than university students. Additionally, belief differences have been found between graduate and undergraduate students. Graduate students tend to believe more in the uncertainty of knowledge, the need for independent reasoning in the acquisition of knowledge, and in the nonlinearity of the learning process than both underclass (i.e., freshmen and sophomores) and upperclass (juniors and seniors) undergraduates (e.g., Jehng et al., 1993; Youn, 2000). Such differences in beliefs are likely to be due, in part, to self-selection. That is, students with more sophisticated knowledge beliefs may be more likely to enroll in a university as opposed to a community college or to pursue a graduate education. However, it is hard to believe that the experiences students have in these institutions do not impact their beliefs in some way.

Given the potential role of maturation and education on the development of students' conceptions of knowledge, it is likely that students' beliefs about knowledge begin to take root and develop much earlier than middle and high school. However, there is a lack of research focusing on how epistemological beliefs develop in younger populations. Although this is due in large part to the difficulty in assessing these beliefs in younger populations, this area of research should not be ignored. As soon as students enter formal learning environments, if not before, it is likely that they begin to form beliefs about what it means to *know* and what knowledge is like. The difficulty is in trying to uncover such beliefs. However, work by theory of mind researchers suggests that such beliefs can be assessed (e.g., Kuhn & Pearsall, 2000).

Specific academic pursuits and domain differences. The previous discussion addressed how students' beliefs vary in relation to their age and education. However, the term *education* was used rather broadly referring to the level or number of years of schooling students completed. In contrast to this approach, some researchers have explored variations in students' knowledge beliefs based on their area of study. Further, others have examined how students' epistemological beliefs may differ depending on the specific body of knowledge under consideration.

Several investigations have conducted between-subject analyses to determine how students' epistemological beliefs vary as a function of their academic major. For instance, using the dualist/relativist classification system developed by Perry (1970), Lonka and Lindblom-Ylanne (1996) examined the beliefs of first-year and fifth-year medical and psychology students. They found that there were more students with dualistic perspectives among the medical students and more students with relativist perspectives among the psychology students.

Researchers employing a multidimensional conceptualization also identified belief differences related to students' academic majors. In these investigations, students' academic pursuits were classified along various dimensions. For example, Jehng et al. (1993) distinguished students majoring in soft fields (i.e., social science and arts and humanities) from those majoring in hard fields (i.e., engineering and business). Evidence suggests that students who major in soft fields tend to believe less in the certainty of knowledge, rely more on their own reasoning abilities in the acquisition of knowledge, and are less likely to view learning as an orderly process than students majoring in hard fields. Youn (2000) offered support for these findings when he attempted to replicate the Jehng et al. study (1993) with a sample of students from the United States and a sample of students from South Korea. Although the nature of the factors Youn identified for the two samples were slightly different, within each sample there were significant differences between students pursuing soft and hard fields of study. Specifically, students majoring in soft fields tended to score higher on Youn's Knowledge factor than students majoring in hard fields.

In another investigation, Paulsen and Wells (1998) classified students' majors along two dimensions identified in Biglan's taxonomy (1973a, 1973b). That is, majors were first identified as being soft (e.g., humanities) or hard (e.g., engineering) and then identified as being applied (e.g., education) or pure (e.g., natural sciences). A series of pairwise comparisons revealed differences among the various majors included in the investigation. For instance, engineering students (i.e., hard, applied field) believed more in the certainty of knowledge than students majoring in humanities and social sciences (i.e., both soft, pure fields), natural sciences (i.e., hard, pure field), and business (i.e., soft, applied field). Education majors were also more likely to believe in the certainty of knowledge than humanities majors (i.e., soft, pure field). Perhaps more informative, however, were the results of a regression analysis, which indicated that students majoring in pure fields were less likely to believe in the certainty of knowledge, the simplicity of knowledge, or the quickness of learning than students majoring in applied fields. Further, students majoring in hard fields were more likely to believe in the certainty of knowledge than students majoring in soft fields of study.

These findings reveal that students' beliefs about knowledge tend to differ depending on the nature of their academic pursuits. However, it is not clear whether students' beliefs are shaped by their particular course of study or if students select their major based on their beliefs. More recent investigations suggest that students' knowledge beliefs may differ according to the domain of knowledge under consideration. Specifically, Hofer (2000) and my colleagues and I (Buehl et al., 2002) have explored differences in students' domain-specific epistemological beliefs.

In her work, Hofer compared students' beliefs about knowledge relative to science and psychology. She found that, regardless of major, students tend to believe that scientific knowledge is more certain than knowledge in psychology. They also view science knowledge as being less justified by personal experience and more likely to be handed down by an authority than psychological knowledge. Further, students believe that truth is more attainable in science than in psychology. When my colleagues and I compared students' beliefs about knowledge in mathematics and history, we found that students believe that mathematics knowledge requires more effort to acquire and is more fully integrated with knowledge in other areas than history knowledge. This evidence suggests that beliefs differences between academic majors may have emerged due to the type of knowledge considered when they participated in the aforementioned studies.

Gender. In addition to the role of age and education, researchers have also explored the relationship between students' gender and their knowledge beliefs. Indeed, some of the early works (e.g., Baxter Magolda, 1992; Belenky et al., 1986) were undertaken in an attempt to explore the different perspectives men and women took towards knowledge. An interest in this issue still appears in more recent works (e.g., Hofer, 2000).

With respect to the more unidimensional conceptualizations of beliefs, some have argued that men and women take qualitatively different approaches to knowledge (e.g., Baxter Magolda, 1992; Belenky et al., 1986). King and Kitchener(1994) and Kuhn (1991) took a different approach and compared the beliefs of males and females using the same coding system. However, this work has been inconclusive. Some studies indicate there are no differences between the beliefs of men and women, while others show a mixed pattern of results. That is, in some investigations women are identified as having more sophisticated beliefs, whereas in others the reverse is true. Further, the researchers suggest that apparent gender differences may be attributable to other variables, such as educational level and ability (King et al., 1994).

Those studies that have taken a more multidimensional approach to the conceptualization of beliefs have also addressed potential gender differences in students' knowledge beliefs. In several investigations, female students were identified as expressing more sophisticated beliefs with respect to the certainty of knowledge (Bendixen, Schraw, & Dunkle, 1998), speed of learning, and students' ability to learn (Neber & Schommer-Aikins, 2002; Schommer, 1990, 1993a; Schommer & Dunnell, 1994; Schommer et al., 1997). Further, these differences may increase with age. Specifically, Schommer-Aikins and her colleagues (Neber & Schommer-Aikins, 2002; Schommer et al., 1997) found that differences between girls' and boys' beliefs about the speed of knowledge acquisition were greater at the end of high school than they were in elementary school or the beginning of high school. Evidence suggests that over time girls believe less in the quickness of learning whereas boys' beliefs remain relatively similar (Neber & Schommer-Aikins, 2002). Despite the evidence of potential gender differences in students' knowledge beliefs, several investigations did not identify differences in students' beliefs by gender (Buehl et al., 2002; Chan & Elliot, 2002; Hofer, 2000). Although gender differences in students' epistemological beliefs will no doubt continue to be an area of interest to researchers, this discussion may benefit from exploring potential reasons for and implications of such differences (Brabeck & Larned, 1996).

Culture. In contrast to the issue of gender, there is a paucity of empirical work examining the role of culture with respect to students' knowledge beliefs. Additionally, the existent research has not been conducted in a systematic manner. In one investigation, Hall, Chiarello, and Edmondson (1996) found that students' beliefs about knowledge were significantly related to their knowledge of their own culture, as well as their exposure to television and print resources. Specifically, students with more cultural knowledge and exposure to television and print resources tended to believe less in the certainty and simplicity of knowledge. These findings suggest that students' cultural environment may impact their knowledge beliefs. However, the researchers were not specifically concerned with relationship between cultural knowledge and epistemological beliefs.

Further, as previously noted, the majority of the research has focused on student samples from the United States and other Western countries. Consequently, little is known about how well the proposed models and measures of beliefs reflect the knowledge beliefs of students in non-Western counties. The few investigations that have explored the beliefs of students in Non-Western countries suggest that new models and measures may be needed.

In my search of the literature, I identified four studies that examined the epistemological beliefs of students in Asian countries. Specifically, Chan and Elliot (2002) explored the beliefs of teacher education students in Hong Kong, Young and his colleagues (Youn, 2000; Youn et al., 2001) addressed the beliefs of high-school and college students in South Korea, and Qian and Pan (2002) the beliefs of high-school students in China. Further, in the studies by Youn (2000) and Qian and Pan (2002), students from the United States were also sampled for the purpose of making direct comparisons. The SEQ or an instrument derived from the SEQ (e.g., JEQ) was used to assess students' beliefs. However, in each case there were problems in using this as a measure of students' beliefs.

For instance, when Qian and Pan (2002) applied the three-factor belief study previously identified in a study by Qian and Alvermann (1995), the reliability of the Certain-Simple Knowledge factor for the Chinese sample was extremely low (i.e., .27). In another study, Chan and Elliot (2002) had to significantly modify the SEQ by eliminating, adding, and rewording items to obtain a factor structure similar to the one identified by Schommer-Aikins (Schommer, 1990). However, even after these modifications, the nature of the factors that emerged from their revised instrument were slightly different from those of Schommer-Aikins (Table 2). Most notably, they identified a factor they referred to as Learning Effort/Process. Items associated with this factor addressed the effort needed to acquire knowledge as well as the importance of learning processes as opposed to facts.

Similarly, when Youn and his colleagues (Youn, 2000; Youn et al., 2001) used the JEQ, they identified a two-factor belief structure instead of the five factors identified by Jehng et al. (1993). Although a two-factor solution also emerged in a comparison sample of college students from the United States (Youn, 2000), there were differences in how the various items loaded on the two factors (Table 2). Specifically, for the sample of Korean college students, items related to beliefs about the source of knowledge loaded with items related to the speed of learning and the innateness of ability. In contrast, for the American sample, items related to the source of knowledge loaded with items related to the certainty and simplicity of knowledge, as Schommer-Aikins and others would predict (e.g., Cole et al., 2000; Schommer, 1994).

Chan and Elliot (2002) and Youn (2000) identified students' surrounding cultures as an explanation for variations in the factor structures. Specifically, Chan and Elliot referred to the Confucian heritage of the Chinese culture that values hard work and effort whereas Youn described how the student-teacher relationship in Korea differs from that found in the United States. Additionally, Youn et al. (2002) investigated how students view themselves in relation to others (i.e., self-construal) and found that an independent self-construal, typical of Western cultures, was related to students' knowledge beliefs, while a interdependent self-construal, typical of non-Western cultures, was not.

This work suggests that the current conceptualization of beliefs may not capture the nature of knowledge beliefs in other cultures. Consequently, it is not appropriate to simply administer the current epistemological measures to individuals in other countries and examine group differences. Instead, we need to explore potential differences in the structure and nature of students' knowledge beliefs, perhaps by using interviews and more qualitative methods. Interestingly, Chan and Elliot (2002) and Youn (2000) also discussed how their respective cultures are slowly changing due to the Western influence. Thus, the epistemological beliefs that emerge from future investigations may offer a depictions of cultures in transition.

Ability and intelligence. Students' epistemological beliefs have also been consistently correlated to verbal ability scores from various measures (e.g., Cognitive Abilities Tests, SAT, ACT; Hall et al., 1996; Kardash & Howell, 2000; Schommer, 1990, 1993; Wood & Kardash, 2002). Although the implications of this relationship are rarely discussed, researchers have controlled for verbal ability in multiple studies examining the relationship between epistemological beliefs and various learning outcomes (e.g., ; Hall et al., 1996; Kardash & Howell, 2000; Schommer, 1993b). That is, they have used verbal ability scores as covariates in an attempt to account for a third variable explanation of identified effects.

Home environment. With regard to other learner characteristics, in her early work, Schommer-Aikins (Schommer, 1990, 1993a) examined epistemological beliefs in relation to students' home environment. Specifically, she examined how well variables representative of students' upbringing, such as parents' occupation and education, adherence to rules, and encouragement toward independence, predicted students' epistemological beliefs (Schommer, 1990). She also examined the differences between the beliefs of junior college and university students after taking variables related to students' upbringing into account. Parents' level of education, opportunities for independence, and adherence to rules were significantly related to students' beliefs about the simplicity of knowledge and the speed of knowledge acquisition (Schommer, 1990, 1993a). That is, students who were encouraged to make decisions independently and question their parents, as well as students of more educated parents, tended to believe less in the simplicity of knowledge. Similarly, with higher levels of parental education and more independent decision making students believed less in the quickness of learning. Despite the apparent role of the students' home environment on their beliefs about knowledge, most recent studies have not explored epistemological beliefs in relation to such variables.

Summary. Epistemological beliefs have been examined in relation to various learner characteristics (e.g., age, gender, and home environment). In much of this research, it is implied that these characteristics exert an influence on students' epistemological beliefs. However, this assumption of causality is often based on correlational research and variables are typically assessed in the same sitting. Consequently, variables may not be causally related or the direction of causality may differ from what is hypothesized.

For example, variations in epistemological beliefs have been identified with respect to students' academic major. Did students' classroom experiences relative to this major influence their beliefs *or* did they choose their major due to their pre-existing beliefs about knowledge? To address such issues, the literature would benefit from longitudinal investigations that, over time, examine students' beliefs in relation to those factors believed to impact their knowledge beliefs. For instance, students' epistemological beliefs could be assessed when they enter college and at various points throughout their college careers. The changes in their beliefs could then be examined in relation to the types of courses they take as well as the major they choose.

Some of the variables studied in relation to epistemological beliefs are relatively stable or fixed (e.g., gender and culture). Thus, questions about the direction of causality are not relevant. Further, few studies have examined epistemological beliefs in countries other than the United States. Those that did indicate that the nature and function of students' epistemological beliefs may vary depending on the larger cultural context. Consequently, there is a need to explore epistemological beliefs in societies other than the United States. Additionally, exploring *why* beliefs vary by gender and culture may yield additional insights into students' knowledge beliefs.

Epistemological Beliefs and Learning Environments

In addition to examining how epistemological beliefs are related to various learner characteristics, several investigations have explored differences in epistemological beliefs due to specific forms of instruction. Examination of these studies reveals that different approaches (e.g., between-subjects vs. repeated measures designs) have been taken to determine how instruction impacts students' knowledge beliefs. The results of these investigations are discussed according to the design of the study.

Correlational and between-subject analyses. Students' experiences in the classroom are believed to influence their beliefs about knowledge. To explore this issue, Neber and Schommer-Aikins (2002) examined students' epistemological beliefs in relation to their perceptions of the learning environment. Specifically, students' ratings of the extent to which their science learning environment supported exploration and investigation were examined in relation to six epistemological belief subset scores obtained from the SEQ. A negative correlation was identified between students' rating of exploration in the classroom and their belief that success was unrelated to hard work.

This finding indicates that students in learning environments perceived to support exploration also tend to believe that learning requires work and effort. However, this finding is based on self-reported data (i.e., students' perception of the learning environment) and correlational analyses. Thus, it should be viewed with caution.

As opposed to relying on students' perception of the learning environment, Hofer (1999) compared the beliefs of students taught with two different instructional approaches. Specifically, some sections of a college calculus course were taught using "New Wave" methods that emphasized active learning, collaboration, and a text that took a more problem-based approach to learning. Other sections of the same course were taught using more traditional methods of lecture and demonstration, presenting topics sequentially. Students did not know how the different sections would be taught prior to registration. An assessment of students' beliefs about mathematics knowledge revealed that students who learned calculus using the "New Wave" methods believed less in the simplicity of mathematics knowledge than students enrolled in the more traditional course. There were no significant differences between the instructional contexts with respect to students' beliefs about the isolation of mathematics knowledge. However, although students from the two instructional contexts were not significantly different with respect to their prior achievement and calculus background, there may have been pre-existing differences in students' mathematics beliefs.

Within-subject analyses. In contrast to the studies by Neber and Schommer-Aikins (2002) and Hofer (1999), two additional investigations examined differences in students' beliefs before and after different educational experiences. For example, Cole et al. (2000) assessed the beliefs of underprepared college freshman at the beginning and at the end of a five-week study skills course. Although this course was not specifically designed to address students' beliefs about knowledge, changes in beliefs were identified. At the end of the five-week course, students believed less in the quickness of learning. However, students demonstrated stronger beliefs about the rigidity of learning and authority figures as a source of knowledge at the end of the course than they did at the beginning. Such decreases in the sophistication of students' beliefs were not anticipated. The authors attributed these results to college instructors' heavy reliance on lecturing as the primary source of learning and information.

Another study employing a within-subject design also found unexpected changes in students' knowledge beliefs (Clareabout & Elen, 2001). In this investigation, the researchers created a technology-supported learning environment based on specific learning and design principles. After working in the multidisciplinary, problem-based learning environment for eight weeks, students exhibited a decreased belief in the need for effort to acquire knowledge. The findings of the Cole et al. (2000) and Clareabout and Elen (2001) studies indicate that the instruction students receive may work to change their knowledge beliefs. However, despite good intentions, such experiences may not have a positive impact on students' beliefs.

Between- and within-subject analyses. Investigations by Tsai (1999b) and Brownlee, Purdie, and Boulton-Lewis (2001) also examined how students' beliefs change due to specific forms of instruction. In contrast to the Cole et al. (2000) and Clareabout and Elen (2001) investigations, students held more sophisticated beliefs about knowledge after the instructional period than they did at the beginning. For instance, Tsai examined the beliefs of eighth-grade females enrolled in science classes taught using a Science-

Technology-Society (STS) instructional approach and compared them to female students in more traditional science classes. The STS instructional unit presented science from various perspectives, incorporated inquiry-based exploration and a variety of instructional resources (e.g., newspaper, internet), and addressed epistemological issues such as why and how scientists develop scientific knowledge. Tsai found that students in the STS classes had more constructivist views of knowledge at the end of the eight-month instructional unit than students enrolled in a more traditional science class (Tsai, 1999b). Additionally, when Tsai grouped students based on their initial beliefs about scientific knowledge, he found that students with constructivist views of knowledge remained relatively constant whereas those with more empiricist or mixed views of scientific knowledge demonstrated a shift in their beliefs over the course of the unit.

Similarly, in their work with pre-service teachers, Brownlee et al. (2001) found belief differences between students in two different sections of an educational psychology course. Students attended the same lectures and met separately for tutorial groups. In the tutorial sections, students in the treatment group regularly discussed and reflected on the course content in relation to their epistemological beliefs, whereas students in the control group simply interacted with the course content. Students in the treatment condition expressed less of a belief in the certainty of knowledge and the quickness of knowledge acquisition at the end of the year-long course than they did at its outset. Students in the control condition, however, expressed more naïve beliefs with respect to the speed of knowledge acquisition at the end of the course than they did at the beginning. Their beliefs about the certainty of knowledge did not significantly change.

Thus, while the treatment group developed more sophisticated beliefs, the beliefs of the control group either remained the same or became more naïve.

Summary. Based on the works just discussed, it appears that students' epistemological beliefs are impacted by the experiences they encounter in educational environments. However, there is variation as to the nature of this impact. Some studies found that students developed what researchers consider to be more sophisticated epistemological stances, while other investigations found that students' beliefs decreased in sophistication. To understand the apparent discrepancies in these findings, it is important to consider how the investigations differed from one another, particularly the works by Cole et al. (2000), Clareabout and Elen (2001), Tsai (1999b) and Brownlee et al. (2001). In addition to the different experimental designs, these investigations differed in two important respects. First, there were variations with regard to the length of the instructional unit. Cole et al. (2000) and Clareabout and Elen (2001) examined changes in students' beliefs after five to eight weeks of instruction, while Tsai (1999b) and Brownlee et al. (2001) examined changes due to instructional units that lasted eight months to a year. Perhaps a more extended interaction with the learning environment is needed in order for a change in beliefs to occur. Tsai's (1999b) study supports this hypothesis. In his investigation, he assessed students' beliefs at the beginning, middle, and end of the eight-month period. Students in both instructional conditions held similar beliefs at the first and mid-semester evaluations. It was not until the final assessment that significant differences in beliefs were apparent.

Second, there were variations in the nature of the learning environments. That is, the instructional units implemented by Tsai (1999b) and Brownlee et al. (2001) were specifically designed to impact students' belief systems. Cole et al. (2000) and Hofer (1999) examined the effects of pre-existing classes that were not specifically intended to alter students' beliefs. Although Clareabout and Elen (2001) designed a technology-supported learning environment, it was not created to specifically address students' knowledge beliefs. This suggests that for a desired change in beliefs to occur, instructors must consider such beliefs specifically as they plan the learning experience.

Based on an analysis of the reviewed studies, it appears that students' epistemological beliefs are affected by the instruction they receive. Consequently, the instructional techniques teachers choose to implement and the experiences they provide students are important factors in the development of students' epistemological beliefs. However, these studies suggest that if educators want to shape students' beliefs in a particular way, they must explicitly design the instructional unit to address students' beliefs. Further, this research indicates that longer periods of instruction are more likely to bring about changes in students' beliefs. The extant research, however, does not address the longevity of such effects. That is, will students' beliefs revert back to their original state when they are no longer supported by the right forms of instruction? Throughout their education, students typically encounter different teachers each year or semester. How do they negotiate contradictory messages given by different teachers with respect to their beliefs about knowledge? Such issues remain avenues for future research.

Epistemological Beliefs and Cognitive Learning Processes and Outcomes

I have described the identified relationships between epistemological beliefs and various learner characteristics. I also discussed the differences and changes in students' epistemological beliefs associated with various learning environments. In the following pages, I describe the cognitive processes, learning outcomes, and dispositions that have been empirically related to students' knowledge beliefs.

Strategy use. Multiple programs of research have addressed the importance of strategic processing and the conditions necessary for students to learn and regularly use strategies that will help them learn (e.g., Pressley et al., 1992; Weinstein & Mayer, 1986). Within the strategy and self-regulation literatures, a distinction is made between the *cognitive strategies* individuals use to understand the presented material (e.g., rehearsal of facts or elaboration) and the *metacognitive strategies* individuals use to gauge their understanding of the material (e.g., comprehension monitoring and evaluating the use of cognitive strategies). Additionally, some cognitive strategies (e.g., elaboration) require the learner to process information actively and are, thus, considered to be more sophisticated than other cognitive strategies that require lower-level processing (e.g., rehearsal).

Research suggests that epistemological beliefs may be one of the factors that contribute to students' strategy use. Students' beliefs about knowledge have been significantly related to the number and types of strategies that students employ. For example, Kardash and Howell (2000) found that students' beliefs about the speed of knowledge acquisition were related to the number of strategies they used as they read a dual-positional text about HIV and AIDS. Students with more sophisticated beliefs (i.e., those who viewed knowledge acquisition as a gradual process) used more strategies than students' who had more naïve knowledge beliefs (i.e., those who believed that knowledge is acquired quickly).

Various techniques and measures have been used to explore the relationship between students' cognitive strategy use and their epistemological beliefs. For instance, Lonka and Lindblom-Ylanne (1996) examined the strategies students' reported using when they read a given text and classified the strategies as rehearsal or elaborative strategies. They found that students with more dualistic views of knowledge tended to use more rehearsal strategies and fewer elaborative strategies than students with more relativistic views of knowledge. Similarly, Tsai (1998b) found that students with more empiricist views of scientific knowledge used more rote-like strategies, whereas students with constructivist views of knowledge used strategies that allowed them to process the material more deeply.

Others (e.g., Kardash & Howell, 2000; Paulsen & Feldman, 1999) have taken a multidimensional approach to the assessment of students' knowledge beliefs and used the SEQ to assess students' knowledge beliefs and relate them to various measures of strategy use. For example, Schommer et al. (1992), examined students' knowledge beliefs in relation to their strategic processing, as assessed by the *Learning and Study Strategies Inventory* (Weinstein, Palmer, & Schulte, 1987). They found that students' beliefs about the speed of knowledge acquisition were predictive of their use of test preparation strategies, such as memorizing and summarizing. In another investigation, Paulsen and Feldman (1999) assessed students cognitive and metacognitive strategy use with the *Motivated Strategies for Learning Questionnaire* (MSLQ). The cognitive strategies of rehearsal, organization, and elaboration were significantly related to students' beliefs about the innateness of ability. Students' beliefs about the speed of knowledge acquisition and the simplicity of knowledge were also related to the use of elaborative strategies. For each of these relationships, students with less sophisticated knowledge beliefs were less likely to use each strategy. A significant relationship between students' beliefs about the simplicity of knowledge and use of rehearsal strategies indicated that students who viewed knowledge as being isolated tended to use more rehearsal strategies than students who viewed knowledge as more complex and integrated.

Kardash and Howell (2000) used think-aloud procedures to identify the strategies students used as they read a dual-positional text. Reported strategies were coded into seven categories, four of which were representative of cognitive strategies (i.e., accepting ambiguity, establishing intrasentential ties, establishing intersentential ties, using background knowledge). Students' beliefs about the speed of learning were significantly related to the establishment of intrasentential ties and students' beliefs about the certainty of knowledge were significantly related to their establishment of intersentential ties. Students who believed that learning was a gradual process also tended to resolve ambiguity in the text by examining individual words and sentences. Students who viewed knowledge as being less certain and more tentative tended to make connections between the sentences and paragraph in the passage as well as draw inferences based on the reading. However, the additional dimensions of students' knowledge beliefs were not significantly related to the other cognitive strategies identified by Kardash and Howell (2000).

Finally, Hofer identified a small but significant correlation between students' beliefs about the simplicity of mathematics knowledge and elaboration strategies, as assessed by the MSLQ. Specifically, students who endorsed the simplicity of mathematics knowledge (e.g., "Math problems have one and only one right answer") were more likely to use elaboration strategies than students who did not hold such views of mathematics. Although this relationship was in the opposite direction than expected, it may be due to the fact that Hofer assessed domain-specific beliefs, whereas as other investigators assessed students' general knowledge beliefs. Perhaps the relationship between strategy use and knowledge beliefs is different within specific domains.

Overall, these findings suggest students' use of cognitive strategic processing is related to their belief that the ability to learn is more malleable as opposed to being fixed at birth. However, the type of strategies students choose to employ also appear to be related to the sophistication of their beliefs about knowledge. Students with more sophisticated epistemological beliefs tend to use strategies that allow them to process the information more deeply, while students with more naïve beliefs rely on more surface level strategies such as memorization and rote rehearsal.

Similar pattern are apparent with respect to the relationship between students' epistemological beliefs and metacognitive strategy use (e.g., Hofer, 1999; Kardash & Howell, 2000; Neber & Schommer-Aikins, 2002; Paulsen & Feldman, 1999). Specifically, students' beliefs about the innateness of ability (Paulsen & Feldman, 1999), the simplicity of knowledge (Hofer, 1999; Kardash & Howell, 2000; Paulsen & Feldman, 1999) and the need for effort in the acquisition of knowledge (Neber & Schommer-Aikins, 2002) are correlated with their metacognitive processing. A study by Ryan (1984) indicated that students with relativist beliefs about knowledge tend to use different criteria to judge when they have learned (i.e, epistemological standards) than students with more dualistic beliefs. Consequently, the differences in students' cognitive and metacognitive processing may be attributable to varied conceptions of what it means *to know*.

Comprehension and text processing. In addition to strategy use, students' knowledge beliefs have also been related to their comprehension and how they process and draw conclusions from text (e.g., Schommer & Walker, 1995; Schraw et al., 2002). Typically, in these investigations, students read a passage and then complete a test that requires them to recall information they learned from the text or to draw conclusions from the text. Students' performance on these tasks are examined in relation to the various dimensions of their knowledge beliefs.

These investigations indicate that students' beliefs about the certainty and simplicity of knowledge, speed of knowledge acquisition, and the source of knowledge are related to their performance on various comprehension tests (Rukavina & Daneman, 1996; Schommer, 1990; Schommer et al., 1992; Schommer & Walker, 1995; Schraw et al., 2002). However, it is interesting to note that there are variations in these relationships depending on the nature of the text. For instance, students' beliefs about the certainty of mathematics and social studies knowledge predicted their performance on a social studies comprehension test, whereas their beliefs about the simplicity of both mathematics and social studies knowledge predicted their comprehension of a mathematics text (Schommer & Walker, 1995).

Additionally, students' epistemological beliefs are related to their ability to process the textual information and draw conclusions (Kardash & Scholes, 1996; Schommer, 1990). For example, Schommer-Aikins (Schommer, 1990) found that students' beliefs in quick learning predicted oversimplified conclusions whereas their beliefs in the certainty of knowledge predicted overly certain conclusions. It also appears that students who believe that learning should occur quickly tend to distort textual information more often than students who view the acquisition of knowledge as a gradual process (Kardash & Howell, 2000). However, contrary to expectations, students with more sophisticated beliefs about the speed of knowledge acquisition and the certainty of knowledge tend to process the text inaccurately more often than those with naïve knowledge beliefs. Kardash and Howell did not offer an explanation for this finding.

Construction of knowledge and conceptual change. Given the role of epistemological beliefs in students' strategy use, text processing, and comprehension, it is not surprising that such beliefs are also associated with how students construct new knowledge and change their previous conceptions. For instance, Tsai has examined the relationship between students' view of scientific knowledge and growth in their knowledge structures. He found that constructivist views of scientific knowledge are linked to the formulation of inferences and consideration of the limitations of various ideas (Tsai, 1999a), as well as the number of ideas students generate and the complexity among these ideas, even after controlling for prior science achievement (Tsai, 1998b). Students with constructivist views also had fewer misconceptions but took longer to recall information and generate ideas than students with more empiricist views of knowledge. These findings indicate that epistemological beliefs aid students in the construction of new knowledge, but only when there is enough time for them to think through the ideas and make the necessary connections.

There is also evidence to suggest that epistemological beliefs are important forces that aid in shaping and refining students' conceptions and misconceptions. Specifically, Qian and her colleagues (Qian & Alvermann, 1995; Qian & Burrus, 1996) assessed students' epistemological beliefs, using the SEQ, and their prior knowledge with regard to Newton's law of motion two weeks before students read a refutational expository text about the topic. After reading the text, students completed an additional test designed to assess their conceptual understanding of the material as well as their ability to apply what they had learned. A canonical correlation analysis indicated that students' beliefs about the simplicity and certainty of knowledge and their beliefs about the speed of knowledge acquisition were significant predictors of their conceptual understanding and their ability to apply what they learned.

Further, multiple studies indicate that the impact of students' epistemological beliefs on their understanding and cognitive structures may be due to the interaction between students' beliefs and their learning environments. Specifically, some researchers have designed environments meant to foster students' conceptual understanding and examined students' learning and conceptual change in relation to their knowledge beliefs. Of the studies I identified, the majority of them pertained to learning scientific topics (e.g., Tsai, 2000b; Windschitl & Andre, 1998). One study related to students' understanding of calculus (i.e., Dedic, Rosenfield, Cooper, & Fuchs, 2001) and one to the impact of technology on the 20th century, a more ill-structured and multidisciplinary topic (Jacobson & Spiro, 1995). Additionally, in three studies, the learning environments were technology enhanced (e.g., hypertext: Jacobson & Sprio, 1995; computer simulations: Windschitl & Andre, 1998), whereas the other investigations relied on varied forms of text (Rukavina & Daneman, 1996) or classroom instruction (Tsai, 2000b). In each of these studies, students' conceptual understanding varied as a function of both their beliefs and the nature of the learning environment.

For instance, Tsai (2000b) examined the cognitive structures of female Taiwanese students as they learned about light in their tenth-grade science classes. Students were in one of two instructional conditions. The treatment group learned about light using the Science-Technology-Society (STS) instructional practice previously discussed (i.e., science from multiple perspectives, inquiry-based exploration, and varied instructional resources). The control group learned about light from their textbook and more conventional learning strategies (e.g., lecturing, problem exercises). Students' conceptual understanding of light was assessed using concept mapping and their beliefs about scientific knowledge were assessed using Pomeroy's (1993) questionnaire. With respect to the size of students' knowledge structures (i.e., number of linkages among concepts), Tsai (2000b) found that students with more constructivist views of knowledge performed better in the STS treatment condition while students with more empiricist views of knowledge performed better in the more traditional class. However, these differences were only apparent at the beginning stages of the instruction. At the end of the unit, students who received the STS instruction performed better than those in the traditional classroom, regardless of their initial beliefs about scientific knowledge. Perhaps, as previously found (Tsai, 1999b) the STS instruction influenced students' beliefs and their cognitive structures.

In another investigation, Windschitl and Andre (1998) examined college students' conceptual understanding of the human cardiovascular system after interacting with one of two instructional computer simulation programs. In the confirmatory condition, students experienced the simulation using a prescribed set of steps that led to the resolution of 12 questions. This condition was viewed as taking a more objectivist approach to scientific knowledge. The exploratory condition required students to use the same computer simulation program to hypothesize and test possible answers to the same 12 questions. However, they were not given guidance as to the specific steps to follow. This condition was viewed as taking a more constructivist approach to scientific knowledge. Students' epistemological beliefs were also assessed using the SEQ. Posttest assessments of students' conceptual understanding indicated that students with more mature knowledge beliefs (i.e., knowledge is complex and tentative) learned more from an exploratory learning condition (i.e., constructivist approach) than from the confirmatory condition (i.e., objectivist approach). In contrast, students with more naïve knowledge beliefs learned more in a confirmatory condition than from an exploratory condition.

These findings suggest that the effectiveness of different learning environments depends on students' beliefs about knowledge. Additional investigations by Tsai (1998a, 2000a) support this conclusion. Specifically, he found that students with more constructivist views of knowledge preferred learning environments that gave them opportunities to solve real problems, interact, and discuss material with peers, and control the learning activities. By comparison, students with empiricist views preferred the material to be clearly presented in lecture format. Further, constructivist students typically perceived their science classroom as inadequate. Consequently, Tsai (1999b) and Windschitl and Andre (1998) speculate that while students with more naïve knowledge beliefs may benefit from more structured and traditional learning environments, students with more sophisticated beliefs may be stifled in such classrooms, leading to frustration, boredom, and a lack of interest and motivation.

In addition to varied instructional practices, other investigations have examined the interaction between different forms of text and students' knowledge beliefs with respect to conceptual transfer and the integration of information (Jacobson & Spiro, 1995; Rukavina & Daneman, 1996). For example, Jacobson and Spiro (1995) created two conditions in which students explored the impact of technology on 20th century society and culture. Both groups read the same material in hypertext format. However, while one group of students completed a computer-based drill of facts and concepts taken from the reading (Minimal Hypertext/Drill), the other group revisited cases presented in the original hypertext that exemplified different combinations of themes and concepts (Thematic Criss-Crossing Hypertext).

Although the Minimal Hypertext/Drill Group gained more factual knowledge, the Thematic Criss-Crossing Hypertext Group demonstrated more conceptual transfer as assessed by two problem-solving essay questions. Further, with respect to conceptual transfer, there was an interaction between students' knowledge beliefs and their group membership. Specifically, students with more complex knowledge beliefs performed better in the Thematic Criss-Crossing Hypertext Group than they did in the Minimal Hypertext/Drill Group. Students with beliefs that Jacobson and Spiro characterized as simple performed worse in the Thematic Criss-Crossing Hypertext condition than those with more complex knowledge beliefs. These differences were apparent even after controlling for the length of time students studied the learning material.

In another investigation, Rukavina and Daneman (1996) found that with respect to integrating information from text, students with more naïve beliefs about knowledge may need more support. Specifically, they presented high school and college students with texts that discussed competing theories for two ongoing scientific problems (i.e., the extinction of dinosaurs and evolution). For each topic, two sets of texts were developed. The integrated text presented both theories of the scientific problem underscoring the conflict between them. In contrast, the non-integrated texts presented the competing theories but did not specifically mention the conflict between them. Overall, students with more mature epistemological beliefs recalled more details and integrated the textual information more than students with more naïve beliefs about knowledge. However, with respect to integrating the information, there was also an interaction between students' beliefs and the text format. Although students with more mature beliefs performed equally well with both types of text, students with more naïve knowledge beliefs benefited more from the integrated text than from the non-integrated text. Examined collectively, the findings just presented suggest that there is a complex relationship between the learning environment, students' beliefs about knowledge, and growth in students' knowledge and conceptual understandings.

Academic performance. Students' academic performance has been assessed in a variety of ways and examined in relationship to students' knowledge beliefs (e.g., Hofer, 2000; Schommer-Aikins et al., 2000). For instance, some investigations have used more global measures of performance such as students' cumulative grade point average (GPA; e.g., Schommer, 1993b; Youn et al., 2001), whereas others have used course specific measures (i.e., final course grade; e.g., Hofer, 1999), or a combination of both general and specific performance measures (e.g., Hofer, 2000; Mori, 1999). Generally, these investigations identified significant relationships between students' beliefs about knowledge and their academic performance (e.g., Schommer et al., 1997). Further, students' achievement and their beliefs were related even after controlling for prior verbal ability (i.e., Ryan, 1984; Schommer, 1993b).

However, there are variations with regard to which belief factors are related to students' performance. For instance, Schommer-Aikins (Schommer, 1993b) found that all four of her factors (i.e., Certain Knowledge, Simple Knowledge, Quick Learning, and Fixed Ability) were significantly related to high-school students' GPA, even after controlling for students' verbal IQ. However, in another investigation with high school students (Schommer et al., 1997), the only belief factor that significantly predicted GPA was students' beliefs about the speed of learning (i.e., Quick Learning). Hofer (2000) identified significant relationships between first-year college students' beliefs about the simplicity and certainty of knowledge in science and psychology, their GPA, and their grades in the respective courses. In contrast, Tsai (1998b) found that eighth graders' beliefs, about scientific knowledge were not significantly related to their science achievement. These differences may be attributable to the various measures that were used to assess students' knowledge beliefs as well as differences with regard to the sampled population (i.e., middle school, high school, or college students).

Reasoning and problem solving. Students' epistemological beliefs have also been related to various forms of problem solving and reasoning in less academic settings. For instance, with respect to problem-solving, Schommer and Dunnell (1997) examined gifted high school students' responses to a series of ill-structured problems (e.g., why a student cannot read, what to do about a prejudiced neighbor). Beliefs about the certainty of knowledge, speed of knowledge acquisition, and fixed ability predicted the sophistication of students' responses. Additionally, Schraw et al. (1995) found that students' beliefs about the speed of learning were predictive of performance on a well-structured problem-solving task (i.e., a test of syllogistic reasoning).

In another investigation, Bendixen et al. (1998) posited that moral reasoning is influenced by individuals' epistemic beliefs. Using Rest's (1979) *Defining the Issues Test* (DIT) to assess students' level of principled moral reasoning, they found that students' beliefs about the simplicity of knowledge, certainty of knowledge, source of knowledge, and speed of knowledge acquisition were significant predictors of their moral reasoning over and above age, gender, education, and students' syllogistic reasoning abilities. Such findings suggest that the role of epistemological beliefs extends beyond the school environment.

Thinking Dispositions. Additionally, student's epistemological beliefs have been related to a miscellaneous group of constructs most appropriately referred to as thinking dispositions. Specifically, Qian and Alvermann (1995) investigated students' knowledge beliefs in relation to learned helplessness, whereas Kardash and Scholes (1996) explored beliefs with respect to students' Need of Cognition.

For instance, Qian and Alvermann (1995) assessed students' learned helplessness behaviors through a self-report questionnaire, as well as students' knowledge beliefs, using the SEQ. The three knowledge belief factors they identified from the SEQ data were significant predictors of students' learned helplessness. Students with more naïve beliefs about knowledge tended to report more learned helpless behaviors that students with more sophisticated beliefs. However, because the belief factors only explained 5% of the variance in students' learned helplessness, Qian and Alvermann (1995) stated that this finding was inconclusive.

In another investigation, Kardash and Scholes (1996) identified a significant relationship between students' beliefs about authority as the source of knowledge (i.e., Dependence on Authority) and their need for cognition, as assessed by the Need for Cognition Scale developed by Cacioppo, Petty, and Kao (1984). As expected, students' tendencies to not rely on authority figures for knowledge and to reason for themselves were associated with a greater desire to seek out and analyze information as well as engage in abstract thinking. Further, due to this relationship, Wood and Kardash (2002) suggested using need for cognition as a covariate. They wanted to ensure that epistemological beliefs are indeed related to performance outcomes and that the identified relationships are not attributable to a third variable (i.e., Need for Cognition).

Summary. Students' epistemological beliefs are related to a host of cognitive processes and learning outcomes. Typically, more sophisticated epistemological stances are associated with higher levels of cognitive and metacognitive strategy use, comprehension, conceptual change, and academic performance. Thus, it appears that, as hypothesized in the literature, epistemological beliefs impact how students process information. For example, students tend to employ different types of strategies and rely on different standards for knowing depending on their epistemological beliefs (e.g., Ryan, 1984). However, the findings are somewhat mixed depending on the subject matter under consideration and the age of the participants. For instance, students' beliefs about the certainty of knowledge predicted their performance on a social studies comprehension test, whereas their beliefs about the simplicity of knowledge predicted their comprehension of a mathematics text (Schommer & Walker, 1995). Consequently, additional research is needed to examine the relationship between epistemological beliefs and cognitive processing in varied domains.

Additionally, several investigations suggest that the interaction of students' beliefs with the learning environment may exert a unique influence on students' learning and cognitive processing. For example, in the investigation by Windschitl and Andre (1998), students with more mature knowledge beliefs learned more from an exploratory learning condition than from the confirmatory condition, whereas students with more naïve knowledge beliefs learned more in a confirmatory condition than from an exploratory condition. Windschitl and Andre (1998) suggest that students with more sophisticated beliefs may not perform as well under certain conditions due to a lack of motivation.

Tsai also offered this as an explanation for why students with constructivist views of scientific knowledge were outperformed by those more empiricist views of knowledge. Specifically, he proposed that when students' beliefs about knowledge conflict with how a class is taught, students may be less motivated. Based on these findings it is important to explore students' epistemological beliefs in relation to specific types of learning environments in order to understand how this interaction impacts students' learning and motivation.

Identification of General Trends and Gaps in the Epistemological Belief Literature

Based on my review, I would characterize the epistemological belief literature as increasing in specificity while simultaneously broadening the scope of how beliefs are conceptualized and studied. There is a general movement to conceptualize epistemological beliefs as a multidimensional belief system. This provides the opportunity to examine how specific aspects of students' epistemologies function within the learning environment. Further, students' beliefs about knowledge are examined in relation to specific domains of knowledge and in specific contexts. Consequently, the current conceptualization of epistemological beliefs is more comprehensive than that first presented by Perry (1970). At the same time, the literature also offers a broader perspective with respect to students' epistemological beliefs. Recent research has addressed the beliefs of both males and females as well as student populations of varying ages. Additionally, a few investigations have explored the nature and function of epistemological beliefs in non-Western countries. Thus, although the study of knowledge beliefs is becoming more specific in some ways, the field is also expanding to be more inclusive and to more fully represent individuals' beliefs.

Despite the advancements with respect to the conceptualization and study of epistemological beliefs, there is a need for additional research. First, additional theoretical and empirical work is needed with respect to the multiple dimensions of students' knowledge beliefs. In current investigations, students' epistemological beliefs are typically conceptualized as being multidimensional. However, most studies rely on Schommer-Aikins' (Schommer, 1990) model of beliefs. Questions have been raised as to whether all of the dimensions Schommer-Aikins proposed are epistemological (Hofer & Pintrich, 1997). Additionally, there are other aspects of knowledge (e.g., beliefs about the source of knowledge) that Schommer-Aikins has not empirically identified. Consequently, we need to continue to explore the various dimensions of students' epistemological beliefs and propose alternative models. Although Hofer (2000) provides an example of an alternative belief framework, additional work is needed. In particular, it may be beneficial to return to the discipline of philosophy and examine how philosophers throughout the ages dealt with epistemology

Second, concerns related to the measurement of epistemological beliefs need to be more fully addressed. For example, the types of beliefs that emerge in a given investigation depend largely on the measures used to assess students' beliefs. If researchers are interested in a specific aspect of students' epistemological beliefs (e.g., domain-specific beliefs) there must be measures available that assess such beliefs. Additionally, studies of students' epistemologies in non-Western countries suggest that current measures may not be appropriate. Consequently, there is a need to develop reliable and valid measures that are reflective of individuals' beliefs. Further, the literature would benefit from additional investigations aimed at validating and refining existing measures.

Third, although beliefs have been explored in relation to the learner, learning environments, and learning outcomes, there are some inconsistencies with regard to which belief factors are related to different learner characteristics and cognitive, learning outcomes. These inconsistencies and mixed results may be due to the specificity at which beliefs are assessed as well as measurement issues. However, additional replication studies are needed. Further, the literature suggests that students' epistemological beliefs interact with learning environments to produce unique learning outcomes. Studying such interactions in more detail, as well as how students' beliefs are influenced by instruction, may assist educators in creating learning environments that are more conducive to student learning.

Finally, various works have alluded to the relationship between students' epistemological beliefs and motivation (e.g., Hofer & Pintrich, 1997). However, very few studies have examined students' beliefs about knowledge in relation to their motivations or proposed a model of how students' beliefs about knowledge and their motivations may be related. These issues are interesting at a theoretical and a practical level. That is, epistemological beliefs are typically studied in relation to more cognitive learning outcomes whereas motivation constructs have been explored with respect to a variety of achievement behaviors and learning outcomes. Examining students' knowledge beliefs in relation to their motivations may help to expand current understandings and provide additional information with regard to the learning process. Such an understanding may allow educators to structure their classrooms and learning experiences to foster optimal levels of student motivation and understanding.

Academic Achievement Motivation

One of the gaps in current understandings about students' epistemological beliefs pertained to the relationship between students' epistemological beliefs and their motivation. Although various theorists have speculated about this link and referred to its potential importance (e.g., Hofer & Pintrich, 1997), few have empirically examined the relationship between these constructs (e.g., Paulsen & Feldman, 1999). Further, those investigations that have included both epistemological beliefs and motivational variables were often guided by other purposes and research questions and did not systematically explore the relationships between these constructs. Consequently, it is my view that the link between students' epistemological beliefs and their motivation needs to be studied in more detail. To this end, I present an overview of the motivation literature with the intention of proposing a model of the relations between students' epistemological beliefs and motivation and, ultimately, testing a portion of this model.

Motivation is a term used to refer to individuals' desire to act or behave in a particular manner (Weiner, 1992). Defined in this manner, the concept of motivation applies in many contexts and situations. Given my focus on students and academic learning environments, I have chosen the focus on achievement motivation (i.e., motivation in situations related to individuals' competence and achievement-related behaviors; Nicholls, 1984). This form of motivation is particularly relevant to educators who want to understand individual differences in students' academic behavior. In recent years, there has been a proliferation of theories addressing students' achievement motivation. However, it is beyond the scope of this review and the current investigation to examine all achievement motivation theories in relation to students' epistemological beliefs. Consequently, I focus on three approaches to motivation (i.e., goal orientation theory, self-efficacy, and expectancy value theory).

The selection of goal orientation theory, self-efficacy, and expectancy-value theory was based on several factors. Specifically, I wanted to focus on approaches to motivation that were representative of the current literature, potentially related to students' epistemological beliefs, and important to students' learning and achievement. To select the theories, I looked to the current literature, as well as my own understanding and view of the constructs.

For instance, as a way to organize motivation theories, Eccles and colleagues (Eccles, Wigfield, & Schiefele, 1998) proposed that each of the current motivation theories address at least one of three broad motivation questions: (a) Can I do the task?; (b) Do I want to do this task and why?; and (c) What do I have to do to succeed at this task? Initially, I wanted to select approaches to motivation that addressed at least one of these questions. However, upon reflection, I felt that theories related to the third question (i.e., What do I have to do to succeed at this task?) pertained more to students' cognitive processes (e.g., self-regulation). The relations between students' epistemological beliefs and cognitive processing have been explored in previous works. For this review, I wanted to examine the potential links between epistemological beliefs and unexplored aspects of motivation. Consequently, for this review examining the potential relations between students' epistemological beliefs and motivation, I chose to focus on approaches to motivation related to the first two questions (i.e., Can I do the task? and Do I want to do the task and why?).

Of the motivation approaches that address these questions, for the literature review examining the relationship between students' epistemological beliefs and motivation, I chose to examine goal orientations theory, self-efficacy, and expectancy-value theory. Self-efficacy and the expectancy portion of expectancy-value theory are related to the first question of whether students' believe that they can do the task. Goal orientation theory and the value portion of expectancy-value theory pertain to the second question of whether students want to do the task and why. These theories were selected over others (e.g., attribution theory and self-determination theory) because a small number of studies had been conducted that examined these approaches to motivation in relation to students' epistemological beliefs (e.g., Hofer, 1999; Paulsen & Feldman, 1999; Qian & Burrus, 1996). Additionally, for the literature review and development of a model of the relations between epistemological beliefs and motivation, I did not want to focus on just one theory. Instead, I wanted to be able to include as many empirical works in this area as possible. Further, goal orientation, self-efficacy, expectancy beliefs, and achievement values are viewed as important factors related to students' learning and achievement.

In testing the proposed model empirically, I felt that it would be beyond the scope of the present study to examine multiple approaches to motivation in relation to the other variables. Consequently, I chose to focus on expectancy-value theory in the current study. Expectancy-value theory was chosen over goal orientation theory and self-efficacy because this approach to student motivation addresses students' beliefs about what they can do (i.e., Can I do this task?) and students' reasoning for why they want to engage in a task (i.e., Do I want to do this task and why?). Additionally, while the expectancy-value theory proposed by Eccles and Wigfield has been explored with elementary, middle school, and high school students, few studies have examined their model in college populations. Thus, selecting expectancy-value theory as an example of motivation offered the opportunity to explore the Eccles and Wigfield model with a college population. This alone is potentially meaningful with respect to students' learning and academic development.

In the following sections, I overview each of the selected theories of students' motivation (i.e., goal orientation theory, self-efficacy, and expectancy-value theory). For each approach to motivation, I examine how the original theorists define the constructs that are central to each theory, and I briefly discuss how the key constructs have been assessed. Further, I highlight the role of these motivational constructs in the learning process, as well as factors that may impact students' motivation. This portion of the review is not meant to be exhaustive or comprehensive. Exhaustive and representative reviews of the motivation literature, particularly with regard to goal orientations, self-efficacy, and expectancy-value theory, have been published elsewhere (e.g., Pajares, 1996; Pintrich & Schunk, 1996; Urdan, 1997; Wigfield & Eccles, 1992, 2000; Zimmerman, 1995). My intention is to sketch of the motivation literature, presenting the underlying character of this work and highlighting the essential claims and key concepts. In doing so, I hope to focus attention on how epistemological beliefs may be linked to achievement motivation, and perhaps add some depth and greater detail to the existing portrait of motivation and the learning process.

Achievement Goal Orientation Theory

Over the past 20 years, goal theory has perhaps received the most attention within the educational and psychological literatures. Goals are broadly defined as specific representations of what the individual would like to achieve, spurring individuals to action and directing their behavior (Ames, 1992; Dweck & Leggett, 1988). More specifically, *achievement goals* "concern the purposes for achievement behavior" (Ames, 1992, p. 261). Defined in this way, achievement goals relate to more than what students hope to gain from specific actions. Instead, achievement goals pertain to the reasons underlying students' behavior and desire to achieve. Consequently, achievement goals are often viewed as an "organized system, theory, or schema for approaching, engaging, and evaluating one's performance in an achievements context" (Pintrich, 2000a, p. 94). The term *goal orientation* is often used to represent how students' achievement goals direct their behavior and orient them to view academic contexts in a particular light.

Goal Orientations and Their Origins

Within the goal literature, researchers primarily distinguish between two overarching goal orientations. That is, there are goals concerned with learning, effort, and improvement and goals that are concerned with performance, extrinsic incentives, and ability (Anderman, Austin, & Johnson, 2002). These two forms of goals are referred to by a variety of terms that at first appear to be synonymous. However, the differences in terminology actually demarcate varied research programs and theoretical traditions. In an effort to provide an accurate depiction of the literature, I offer a brief discussion of the various ways goals have been defined within each tradition.

Carol Dweck: A social-cognitive approach to personality. Carol Dweck's conceptualization of goals emerged from the personality literature. Specifically, she and her colleagues (e.g., Dweck, 1975; Dweck & Leggettt, 1988) wanted to understand the psychological processes that accounted for differences in individuals' cognition, affect, and behavior. Two major behavior patterns were identified: a mastery-oriented response and a maladaptive, "helpless" response. Individuals who exhibited a mastery-oriented response pattern sought challenging tasks and persisted when obstacles arose. In contrast, individuals who displayed a "helpless" response pattern avoided challenge and tended to give up when faced with obstacles, thereby impacting their performance. Further, studies with children, indicated that reliance on a particular response pattern did not depend on the child's ability level (e.g., Diener & Dweck, 1980; Dweck, 1975; Dweck & Reppucci, 1973). Instead, the children's behavior appeared to be guided by different purposes.

Dweck and collegues (Dweck & Elliot, 1983) considered whether the response patterns were guided by varied goals. This led them to identify two major classes of goals that emerged in achievement situations (Dweck, 1990; Dweck & Elliot, 1983). *Learning goals* were viewed as a desire to "increase…competence by learning something new or mastering a new task" (Dweck, 1990 p. 203). *Performance goals* were viewed as a desire to "gain favorable judgments of…competence and avoid unfavorable ones" (Dweck, 1990, pp. 203-204).

Within this framework, individuals' belief systems were hypothesized to determine which class of goals an individual would adopt. In particular, Dweck and colleagues examined learning and performance goals in relation to individuals' theories of intelligence. Specifically, an incremental view of intelligence (i.e., intelligence is a malleable quality that one can control and increase) was linked to the adoption of learning goals, whereas an entity view of intelligence (i.e., intelligence is a fixed and controllable trait) was linked to performance goals. Given this connection between individuals' beliefs about intelligence and specific types of goals, Dweck's conceptualization of goals did not allow for the adoption of both types of goal orientations simultaneously. Further, it is implied that individuals' goal orientations are a relatively stable trait.

Carol Ames: Goals and classrooms from a social psychology perspective. Carol Ames took a different approach to the study and conceptualization of goal orientations. Specifically, her training in social psychology led to an interest in students' attributions in achievement settings. Drawing on Dweck's work, Ames (1986) speculated that varied goals and behavioral response patterns could be induced by situational factors. For example, she examined the attributions children made for their performance in two task conditions (Ames, 1984). In the individualistic condition, children were encouraged to solve as many puzzles as possible. In the competitive condition, the task was presented to pairs of children and they were directed to solve as many puzzles as possible in order to see who was the winner. Additionally, each child's level of performance (i.e., high vs. low) was manipulated by assigning them puzzles that were or were not solvable. Children who experienced the individualistic condition endorsed more effort attributions whereas children in the competitive condition endorsed more ability attributions. Consequently, Ames concluded that the different responses were elicited by the goal structure of the achievement setting.

In follow-up investigations, Ames initially referred to *mastery-focused* and *ability-focused goals* (e.g., Ames, 1984; Ames & Ames, 1984). Later, she began to use the terms *mastery goals* and *performance goals*, apparently integrating the various perspectives on goals (e.g., Ames, 1992). Specifically, individuals with mastery goals want to reach a deeper level of understanding, recognize the necessity of effort, and value learning and developing new skills. Individuals with performance goals focus primarily on their ability and self-worth, want to do better than others and achieve success with little effort, and want to receive favorable public recognition (e.g., Ames, 1992; Ames & Archer, 1988).

In contrast to Dweck, who focused on the relationship between individuals' theories of intelligence and goals, Ames believed that the goal structure of the classroom impacted students' goals and behaviors. Consequently, she directed her attention to factors within educational settings that created more mastery-oriented and performanceoriented learning environments. Thus, she identified tasks and learning activities, evaluation and recognition procedures, and the distribution of authority and responsibility as key structures that worked to foster or hinder the development of a mastery goal orientation within students. Further, within Ames' conceptualization of goals, a mastery-goal orientation was viewed as more desirable and efforts were directed at how to increase mastery orientations.

Work by Midgley and her colleagues (e.g., Maehr & Midgley, 1991, 1996) demonstrates the impact of the classroom and school structures on students' goals. That is, Midgely and her colleagues worked in conjunction with teachers and administrators over a period of years to re-design school practices and policies to create a mastery-focused environment. In response to the environmental changes, students increased with respect to their mastery goals and academic achievement. These changes occurred in both an elementary and a middle-school setting.

<u>John Nicholls: Views from educational psychology.</u> In contrast to Dweck and Ames, John Nicholls (1984) viewed goals in relation to the interaction between individuals, particularly their beliefs about ability, and environmental factors. Nicholls held that individuals have a natural desire to improve their level of mastery, especially when tasks are moderately challenging, there is no physiological or psychological stress, and there are no, or minimal, extrinsic rewards. He posited that individuals have a tendency to focus on their ability when tasks are tests of valued skills, competition is fostered, and when attention is focused on the self. The terms *task-involved* and *ego-involved* are, respectively, used to refer to these tendencies.

Specifically, an individual with a task-involved orientation has a ”self-referenced definition of success as the gaining of insight or skill or accomplishing something that is personally challenging," whereas an ego-involved orientation "means that to experience success the student must establish his or her ability as superior than that of others" (Nicholls, Cobb, Wood, Yackel, & Patashnick, 1990, p. 110). Individuals' definitions of success are implicit in each of these definitions. That is, success is based on either an internal or external frame of reference. Further, improvement and mastery are central to each orientation, yet serve different purposes. For task-involved individuals, improvement is the end goal whereas for ego-involved individuals improvement and mastery are merely the means necessary to receive the desired recognition.

In addition to task-involved and ego-involved orientations, Nicholls and his colleagues also refer to work-avoidant and academic alienation orientations (e.g., Nicholls et al., 1990; Thorkildsen & Nicholls, 1998). Individuals with a work-avoidant orientation prefer academic work to be easy so that they do not have to exert much effort (Nicholls, 1989). The academic alienation orientation has not been clearly defined (e.g., Thorkildsen & Nicholls, 1998), but based on sample items in published articles, this orientation appears to represent students' desire to not participate in academic activities (e.g., "I feel most successful if I fool around and get away with it"). Although work-avoidant and academic alienation goal orientation have been included in some investigations (e.g., Meece & Holt, 1993; Meece, Blumenfeld, & Hoyle, 1988), these orientations have not received the same level of attention as task-involved and ego-involved goal orientations. One reason for this may be that it is questionable as to whether work-avoidant and academic alienation goals truly represent achievement goals.

That is, they do not provide a reason or purpose for students' achievement or lack of achievement (Urdan, 1997).

Finally, with respect to Nicholls' conceptualization of goal orientations, his assessments of beliefs suggest that students may endorse varied goal orientations simultaneously. In a recent article, Thorkildsen and Nicholls (1998) noted that there is the possibility for individuals to score high and/or low on all of the goal orientation scales, allowing for complex goal profiles.

Synthesizing goal orientation terminology. As indicated above, and discussed elsewhere (e.g., Murphy & Alexander, 2000; Pintrich, 2000a), there is a plethora of terms that refer to two basic goal orientations. The creation of varied terminology was likely intended to indicate particular theoretical approaches and conceptualizations of goal orientations. For instance, Dweck, Ames, and Nicholls each differ with respect to the source of students' goal orientations (e.g., individual beliefs or environmental factors) and the potential to have multiple goal orientations at the same time. Despite such differences, the terms are often used interchangeably or terms from varied traditions are used at the same time (e.g., task-involved and ability orientations, Urdan, 1997). This has created confusion for individuals reading the goal literature with regard to interpreting the results and understanding the assumptions underlying the various investigations. However, overall, mastery (task or learning) goals primarily pertain to an individual's desire to improve at or master the skills required for a particular task. In contrast, performance (ego or ability) goals represent an individual's need to demonstrate particular abilities in relation to others, receive favorable recognition, and avoid unfavorable recognition (Ames, 1992; Blumenfeld, 1992; Dweck & Leggett, 1988;

Meece, 1991; Nicholls, Cobb, Yackel, Wood, & Wheatley, 1990). In the remainder of this review, I will use the terms mastery and performance goals.

Other goal orientations have also been proposed and discussed in the goal literature. For example, work-avoidant goals were proposed by Nicholls (1989) and have been assessed in studied by Meece and others (e.g., Meece & Holt, 1988). Additional goal orientations have also emerged that are similar to the existing conceptualizations of mastery and performance goal. For instance, Hofer (1999) identified an intrinsic goal orientation, representing students' desire to achieve in order to satisfy their curiosity. Others have identified an extrinsic goal orientation (e.g., Pintrich & DeGroot, 1990). This goal orientation is based on individuals' desire to achieve in order to receive grades and other external rewards. The extrinsic goal orientation differs somewhat from a performance goal orientation in that the focus is receiving external reinforcers, as opposed to competition with others.

<u>A reconceptualization of goal orientations.</u> Despite the differences and confounding of terminology, Elliot and Harackiewicz (1996) offered a more detailed and defined analysis of students' goal orientations. Specifically, they noted that the previous conceptions of goals tended to focus on the reasons why students want to achieve competence. Focusing on the attainment of competence represented an approach perspective toward motivation. However, early motivation theorists (e.g., Lewin, 1938; McClelland, 1961) also specified an avoidance component to motivation in which individuals are motivated to act in an effort to *avoid* specific consequence. Initially, some of the goal orientation were defined with this distinction in mind. For instance, Dweck defined performance goals in terms of wanting to "gain favorable judgments

of…competence and avoid unfavorable ones" (Dweck, 1990, pp. 203-204). However, when goals were assessed, this distinction was often blurred or measures focused only on an approach orientation, accounting for some of the mixed results with respect to performance goal orientations.

Consequently, Elliot and Harackiewicz (1996) proposed that the two basic goal orientations (i.e., mastery and performance) needed to be reconceptualized. Specifically, they posited that individuals may engage in achievement behavior in an effort to receive favorable judgment (i.e., performance-approach orientation) or to avoid receiving negative judgments (i.e., performance-avoidance orientation). This theoretical distinction has been supported by their work (e.g., Elliot & Church, 1997; Elliot & Harackiewicz, 1996), and the work of other goal theorist (e.g., Midgely et al., 1998). Further, more recently, Elliot (1999) articulated a 2 x 2 achievement goal framework in which the approach-avoidance distinction was extended to mastery goals. That is, individuals may possess a mastery-approach goals in which they strive to gain competence or a mastery-avoid goals in which they strive to avoid incompetence and misunderstanding.

Investigations conducted thus far suggest that incorporating the approach-avoidance distinction into goal orientation research is an important addition to the literature. For instance, performance-approach and performance-avoidance goals tend to be differentially related to various learning outcomes (e.g., Elliot & Harackiewicz, 1996; Skaalvik, 1997). Additionally, initial investigations using the 2 x 2 goal framework also suggest that mastery-approach and mastery-avoidance goals have different antecedents and consequences (e.g., Elliot & McGregor, 2001).

Reconceptualizing goal orientation theory? In light of the nuances that are now recognized among the various goal orientations, some researchers (i.e., Harackiewicz et al., 2002; Pintrich, 2000b) advocate for a revision of goal orientation theory. Initially, the primary distinction was between mastery goals and performance goals. Within this framework, mastery goals were viewed as the favorable goal orientation that students should adopt. Indeed, a mastery goal orientation was related to many adaptive outcomes (e.g., Ames, 1992; Pintrich & Schunk, 1996). In contrast, the findings with respect to performance goals were somewhat inconclusive. Sometimes they were related to adaptive behaviors and other times to less adaptive behaviors. However, students with mastery goal orientations repeatedly fared better than those with performance goal orientations, and consequently, a mastery goal orientation was considered to be ideal. This approach is referred to as *normative goal theory* (Pintrich, 2000b).

Recently, the normative approach to goals has been challenged (Harackiewicz, Barron, & Elliot, 1998; Pintrich, 2000b) and theorists have proposed an enhancement view of goals in which the specific goal orientations were less important than the affective and cognitive consequences of the goals (Pintrich, 2000b). Specifically, performance-approach goals have been associated with more adaptive patterns of behavior and high levels of performance than performance-avoid goals (e.g., Elliot, 1997; Middleton & Midgely, 1997; Skaalvik, 1997). Further, performance-approach goals appear to be particularly beneficial when they are combined with high levels of mastery goals (e.g., Midgley et al., 2001). Consequently, some theorists have suggested that performance-approach goals should be fostered in conjunction with mastery goals. However, other prominent goal theorists do not feel that such a revision is needed and that the focus should remain on mastery goals (e.g., Midgley et al., 2001). A heated debate with regard to this issue is likely to continue for some time (e.g., Harackiewicz et al., 2002; Midgley et al., 2001; Pintrich, 2000b).

Measurement

Goal theorists have primarily relied on two methods in their investigations of individuals' goal orientations. Goals have either been experimentally manipulated, typically in laboratory settings, or assessed with a questionnaire.

Experimental manipulation of goals. In some investigations, particularly in the early studies on goals, researchers experimentally induced mastery or performance goals by varying the directions for a specific task (e.g., Ames, 1984; Elliot & Dweck, 1988; Elliot & Harackiewicz, 1996). For instance, as previously discussed, Ames (1984) presented children with a series of puzzle tasks. In one condition (i.e., individualistic), the task was administered individually and children were encouraged to solve as many puzzles as possible. The second condition (competitive) was administered to pairs of children who were encouraged to compete to see who was the best.

Elliot and Harackiewicz (1996) manipulated goals in a similar manner when they investigated performance-approach and performance-avoidance goals in college students. Specifically, students were presented with word-find puzzles in four different conditions. In the performance-approach and performance-avoidance conditions, students were told that their performance would be compared to other students. Students in the performance-approach condition were assured that students do well on the task, but that there was opportunity to demonstrate their superior ability. In contrast, students in the performance-avoidance condition were told that some students stood out due to their poor performance and that this was their opportunity to demonstrate that they did not have a low puzzle solving ability. A neutral condition was created by simply telling students they would have the opportunity to demonstrate their puzzle solving abilities with no reference to achieving superior performance or avoiding low performance. Additionally, a mastery condition was created by removing the competitive element (i.e., comparing performance to other students) and instructing students that they would be given their score after the task was completed.

Although such manipulations appeared to be effective with regard to orienting individuals to achieve for a specific reason, the ecological validity of the findings are suspect (Urdan, 1997). Specifically, investigations were typically conducted in laboratory settings and puzzle-solving tasks were typically used. Consequently, the impact of the varied goal orientations in more traditional academic environments was unclear.

Questionnaires assessing student goals. Other investigations have studied students' goal orientations by assessing them in more realistic settings (i.e., classrooms). A variety of measures have been designed for this purpose (e.g., *Survey of Approaches to Learning* (SAL) and *Patterns of Adaptive Learning* (PALS); Miller, Greene, Gregory, Montalvo, Ravindran, and Nichols, 1996; Midgley et al., 2000). Typically, students are presented with a series of items and are asked to rate their agreement or disagreement with each item using a Likert scale. The wording of the items and the scoring procedure depend on the conceptualization of goals that is employed. For instance, items on the PALS assess students' mastery, performance-approach, and performance-avoidance goals in school and classroom situations (Midgley et al., 2000), whereas measures developed by Nicholls assess task, ego, and work-avoidant goal orientations (Nicholls, 1989). The

Nicholls measures have an affective timing component that is absent in many of other measures (Urdan, 1997). That is, each item specifically asks students to indicate "when they feel successful."

Additionally, there are some differences with the level of specificity at which students' goals are assessed. Some measures focus on students' goals in particular subject areas (e.g., mathematics: Cobb, Wood, Yackel, & Nicholls, 1991) and other assessments are more global, referring generally to schoolwork without indicating a specific subject area (Ames & Archer, 1988; Midgely et al., 1998). The differences in specificity appear to be partially a function of age. For example, Midgely and her colleagues (Middleton & Midgely, 1997; Midgely et al., 1998) used more general measures with younger students and the more specific measures with older students. However, the domain-specificity in academic goal orientation is an area of research that requires additional investigation.

Overall, questionnaires appear to be a relatively effective means of assessing students' goal orientations and studying them in relation to other relevant constructs. Often researchers have iteratively revised their measures using exploratory and confirmatory factor analytic techniques, as well as refined definitions of the various goal constructs (Midgley et al., 2000). These efforts have yielded relatively consistent results with respect to mastery goals, but the assessment of performance goals has been somewhat less precise (Urdan, 1997). Specifically, assessment of performance goals sometimes incorporates other types of goals and beliefs (e.g., social goals: Meece & Holt, 1988).

<u>Consequences of Goal Orientations</u>

The consequence of different goal orientations have been explored in multiple studies. Further, these findings are summarized in various review articles (e.g., Midgely et al., 2000; Pintrich & Schunk, 1996; Urdan, 1997). From these works, I identified some of the most consistent findings with respect to goal orientations. Further, I group these findings based on whether they pertain to behavior and cognition or affect and motivation, as others have also done (Dweck & Leggettt, 1988).

<u>Behavior and cognition.</u> Goal orientations have been examined in relation to a variety of adaptive and maladaptive learning behaviors (e.g., task choice, persistence, strategy use). In these investigations, mastery goals are typically related to more adaptive behaviors. That is, students with mastery goals tend to choose more challenging tasks, persist when difficulties are encountered, use more deep-processing strategies, employ more metacognitive strategies, and ultimately perform better on experimental tasks and in classroom settings than individuals with performance goals (e.g., Ames, 1992; Anderman & Maehr, 1994). Additionally, individuals with mastery goal orientations tend to attribute failure to a lack of effort, as opposed to a lack of ability (Dweck & Leggettt, 1988). This allows them to be more resilient when they do not succeed at a task.

Initial investigations indicated that individuals with performance goals were in a precarious position. They tended to choose less challenging tasks than mastery-oriented individuals, but still felt compelled to demonstrate a high level of performance (Elliott & Dweck, 1988; Pintrich & DeGroot, 1990). Consequently, the task they chose also could not be too easy. Additionally, performance goals were associated with surface-level strategy use, a tendency to give up when obstacles arose, and to attribute failure to a lack of ability (e.g., Meece et al., 1988). However, there were also instances in which performance goals were either positively related to adaptive behaviors or unrelated to adaptive and maladaptive behaviors (e.g., Ames & Archer, 1988; Midgely et al., 1996; Nicholls, Patashnick, & Nolen, 1985; Pintrich & Garcia, 1991).

Some of this confusion may be due to the confounding of performance-approach and performance-avoidance goals. More recent investigations that have made this distinction indicate that performance-approach goals are associated with more adaptive behaviors than performance-avoidance goals. For instance, performance-approach goals have been positively related to effort and performance (e.g., Barron & Harackweicz, 2001; Elliot, McGregor, & Gable, 1999), whereas performance avoidance goals have been repeatedly linked to disorganized studying, shallow processing of information, and a lack of help-seeking behavior (e.g., Elliot & McGregor, 2001; Middleton & Midgley, 1997; Sklaavik, 1997). However, performance approach goals are positively correlated with some maladaptive behaviors, such as shallow information processing, indicating that they are not as adaptive as mastery goals (e.g., Elliot et al., 1999; Middleton & Midgley, 1997).

Affect and motivation. There are also differences among the varied goal orientations with respect to students' motivation and affect. Again, mastery goals tend to have more positive consequences. Students with a mastery orientation tend to be more intrinsically motivated and have more positive feelings toward school (e.g., Ames, 1992; Maehr & Midgely, 1996). In contrast, students with performance goal tend to have more negative feelings toward school and have lower levels of intrinsic motivation (e.g., Ames, 1992; Dweck & Leggettt, 1988; Nicholls, 1989). Researchers have also found that students' academic self-efficacy is positively related to their performance approach orientations but negative related to their performance avoidance goals (e.g., Elliot & Church, 1997).

Summary and Salient Gaps in the Goal Orientation Literature

Despite, or perhaps because of its prominence in the motivation literature, goal orientation theory is plagued by an abundance of terms (Murphy & Alexander, 2000). Although the differences in terminology at one point demarcated important distinctions and theoretical traditions, many, particularly those new to goal theory, do not respect, or even have knowledge of these boundaries. Consequently, the terms are often used interchangeably. However, if the distinctions among the varied conceptions of goals (e.g., learning goals vs. mastery goals vs. task-involved goals) are significant, readers need to be better educated with respect to these differences and a more specific lexicon should be used in discussions of goal orientations.

As I discussed, the initial conceptualizations of goals (e.g., Ames, 1984; Nicholls, 1984) tended to focus on the approach component of motivation and, more recently, the avoidance aspect of motivation has been incorporated. Specifically, distinctions are now made between performance-approach and performance-avoidance goal orientations. To a lesser extent, mastery-approach and master-avoidance goals have also been discussed.

Further, the extant goal literature indicates that students' goal orientations have important consequences with respect to their learning and motivation. Although mastery goals consistently result in more adaptive behaviors, the implications of the mastery-approach/mastery-avoidance distinction have not been fully explored. Additionally, the utility of performance goals is still not entirely understood. This is due in part to the confounding of the performance-approach and performance-avoidance orientations. Recent research indicates that studying these constructs separately will help to dispel some of the confusion. However, more work is needed in this area, if we are to understand the role of both performance-approach and performance-avoidance goals as well as to appreciate when performance-approach goals may be appropriate.

In addition to the consequences of the varied goal orientations, it is essential to more deeply explore the antecedents of students' goals. That is, Dweck proposed that goals were a result of individuals' belief systems. Ames held that the goal structure of the environment was the primary determinant of individuals' orientations, whereas Nicholls viewed both individual characteristics and the environment as contributing factors to students' goals. An extensive body of work supports the view that the environment is instrumental in shaping students' goal orientations (e.g., Ames, 1992; Maehr & Midgely, 1996; Midgely, 2002). However, the impact of individuals' belief systems on their goals has not been as systematically investigated. Consequently, we need to explore how additional aspects of individuals' beliefs (e.g., their epistemological beliefs) may affect their academic goal orientations.

Finally, throughout this discussion and in the literature, achievement goals are defined as the reasons or purposes for engaging in achievement behavior. To address this issue, various goal orientations have been proposed and studied in numerous investigations. However, it may be fruitful to conduct a similar line of research exploring the reasons and purposes students have for *not* engaging in achievement behavior. Although the work avoidant and academic alienation orientations proposed by Nicholls tap into this idea, they are more indicators that students do not want to achieve than they are indicators of the reasons *why* students do not want to achieve.

Self-Efficacy

In response to behaviorist views of learning, Albert Bandura developed social learning theory, which was later expanded and renamed social-cognitive theory. Specifically, Bandura proposed a transactional view of the self and society in which environmental factors, personal factors, and behavior reciprocally influence one another (Bandura, 1986). Although individuals do not have complete control over environmental factors, they can act to bring about desired behaviors and outcomes, thereby exercising some control. In this framework, Bandura recognized the importance of beliefs, self-perceptions, and expectation with regard to how, or even *if,* individuals will act. In particular, he focused on self-efficacy as a key component with regard to individuals' behavior and studied it extensively in a variety of contexts (e.g., cognitive functioning, athletic function, and health functioning). Due to the predictive and explanatory power of self-efficacy, other researchers also investigated the construct, particularly in relation to academic motivation and achievement (e.g., Pajares & Miller, 1994; Schunk, 1991; Zimmerman, Bandura, & Martinez-Pons, 1992). In such contexts, researchers often use the term academic self-efficacy to refer to students' efficacy beliefs with respect to academic tasks.

Defining Self-Efficacy and Differentiating it from Outcome Expectancy Beliefs

Within his social-cognitive model, Bandura discussed two types of expectancies for success: self-efficacy beliefs and outcome expectancy beliefs. *Self-efficacy* is defined as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). Given this definition, individuals' efficacy beliefs are directly tied to concrete observable actions. However, Bandura differentiates self-efficacy from the outcomes that are expected from a specific course of action. That is, self-efficacy beliefs represent beliefs about one's capability to execute a course of action whereas *outcome expectancy beliefs* pertain to the consequences that are anticipated to occur from that course of action. Drawing the distinction between these constructs underscores that individuals do not exist in isolation and that outcomes are also impacted by environmental and external factors. Further, based on the the manner in which self-efficacy and outcome expectancies are defined, self-efficacy beliefs precede outcome expectancy beliefs. Thus, outcome expectancy beliefs are greatly influenced by self-efficacy beliefs.

For example, a student may believe that he or she is capable of studying the required information and performing well on a test (i.e., self-efficacy), but a host of factors (e.g., an unexpected illness, a low level of personal effort, or biased grading) may impact what the student believes with regard to his or her actual performance (i.e., outcome expectancy). Consequently, the student's belief about his or her capabilities may differ from what is expected to happen in a given situation. Even so, in order to expect a particular outcome, the student must believe in his or her capability to perform the action necessary to attain the outcome.

Despite the conceptual distinction between self-efficacy and outcome expectancy, empirically they often provide similar information. Multiple investigations have found that self-efficacy accounts for much of the variance in outcome expectancies if individuals' performance primarily determines the outcome (e.g., Lent, Lopez, &

Bieschke, 1991; Shell, Murphy, & Bruning, 1989). When an outcome is dependent on other factors in addition to the actual performance, self-efficacy beliefs only account for a portion of the variance in outcome expectancy beliefs (Bandura, 1997). Self-efficacy and outcome expectancy are independent in situations when a desired outcome cannot be produced by any level of competence. Bandura (1997) notes that this often occurs when there is rigid segregation by race, gender, or age. Within the educational and psychological literatures, self-efficacy has received more attention than outcome expectancy. This may be due, in part, to the relationship between self-efficacy (i.e., belief in one's capabilities), prolonged effort, and performance, or an implicit assumption that students' performance is the primary determinant of their academic behavior and achievement (Bandura, 1997).

Sources of Self-Efficacy

According to Bandura, there are four major sources of self-efficacy information: mastery experiences, vicarious experience, verbal persuasion, and physiological and affective states. However, the formation of a self-efficacy judgment is based on the information individuals attend to and use as indicators of their capabilities. The specific configuration of efficacy information that individuals draw from will vary depending on the situation. Further, there are variations with respect to how the efficacy information is weighed and integrated with individuals' previous beliefs about the self. Drawing from Bandura (1997), I briefly discuss each of the four major sources of efficacy information.

Mastery experiences. Individuals' previous experiences are perhaps the most influential determinants of their self-efficacy. Indeed, a successful experience can lead to a greater level of confidence in one's capabilities. However, a number of factors, including prior efficacy, determine whether individuals' self-efficacy improves or dwindles after a specific experience. Other factors include the difficulty of the task and the contextual factors, such as assistance from others or situational impediments. If the task is too easy, efficacy is likely to remain the same. However, if an easy task requires outside assistance, self-efficacy may decrease. Task difficulty is typically judged based on features of the task. When the task is unknown or unfamiliar, individuals often refer to similar tasks that are familiar with known requisite skills in order to assess the difficulty of the task at hand (Trope, 1983).

Expended effort is another factor that influences how mastery experiences influence individuals' self-efficacy. Tasks that require what is perceived to be an excessive amount of effort may negatively impact self-efficacy, particularly if performance is poor (Bandura & Cervone, 1986). That is, if a great deal of effort results in a failing performance, that outcome may be attributed to low capabilities, especially if the task is perceived to be easy (Trope, 1983). Additionally, self-efficacy is impacted by how individuals monitor and reconstruct their previous experiences. Individuals' prior expectations as to the development of their capabilities also plays a role. For instance, selective attention may focus individuals' attention on successful or unsuccessful performances, particularly if they are ahead or behind with regard to the attainment trajectory they anticipated.

<u>Vicarious experiences.</u> Observing others succeed or fail at specific tasks (i.e., vicarious experiences) also provides individuals with information they can use to judge their own capabilities. Vicarious experiences are particularly important when there is no absolute measure of performance and competency is based on normative standards

(Bandura, 1997). In such situations, social comparison provides individuals a basis from which they can judge their own capabilities. That is, when individuals perform better than those they observed, self-efficacy tends to increase. Performance at a level below others, however, can have a negative impact on self-efficacy.

Vicarious experience is also an important source of efficacy information if the task is novel or unfamiliar (Bandura, 1997). By observing others, either in the immediate environment or symbolically represented through various forms of media such as television, individuals gain information about *how* to accomplish the task and they are provided a basis for judging *if* success is possible. The degree to which observational learning occurs depends on individuals' abilities to process what they observe. Specifically, they must be able to attend to the observed behavior and retain what they observe. Further, individuals must translate what they observed into a concrete course of action. Motivational processes then determine whether the course of action is initiated (Bandura, 1986).

In addition to processing the observed experience, a number of factors determine how individuals' self-efficacy is impacted. For instance, the degree of similarity between the observed model and the individual is an important factor. Individuals are more likely to believe that they can succeed if they observe a successful performance by someone with similar attributes (e.g., age, gender, perceived ability level). Moreover, observing several people succeed has a greater impact that observing only one other person. An additional factor that contributes to the saliency of vicarious experience is the amount of uncertainty individuals feel with respect to their capabilities. If individuals are relatively certain of their success or failure, observing others succeed or fail will have less impact than when individuals are unsure if they can accomplish the task.

Verbal persuasion. A third major source of efficacy information is the input individuals receive from others in the form of feedback and verbal persuasion (Bandura, 1997). Verbal persuasion does not influence self-efficacy as directly as do mastery and vicarious experiences, but the verbal information provided by others can contribute to individuals' success. Specifically, verbal persuasion can prime individuals to increase or curtail the amount of effort exerted in an activity. For example, when a student knows her teacher thinks she can succeed at a task, she may try harder, increasing her likelihood for success.

The impact of verbal input from others depends on several factors. First, the framing of the verbal feedback influences how that feedback is interpreted and used to form efficacy judgments. For instance, focusing on improvement and gains with respect to skills and abilities has more positive impact on efficacy than when deficits are highlighted. Second, the source of the verbal feedback is important. Individuals are more likely to be persuaded by those they perceive as knowledgeable and credible. If the person offering verbal support knows very little about the task or if he or she is not reliable, that person's comments will have less impact.

Third, the degree of disparity between the individual and the person offering verbal imput will also determine how much efficacy is impacted. That is, there is often a discrepancy between individuals' beliefs about their capabilities and what others believe they can do. Individuals are more likely to believe persuasive remarks if there is only moderate disparity between their beliefs and what others are expressing. Additionally, although disparate views may be believed when the performance or task is in the distant future, there is a lower level of optimal disparity for tasks that are more proximal.

Physiological and affective states. Finally, physiological and affective states provide individuals with information about their capabilities (Bandura, 1997). The impact of this information depends on individuals' abilities to attend to and interpret physiological cues. Specifically, the interpretation of bodily states involves identifying the sources of arousal and attaching an emotional label to the bodily state (e.g., fear, anger, sorrow). Individuals may then use this information to form a judgment about their capabilities. For example, a student is called on to answer a problem in a math class and notices that he feels warm and has sweaty palms. If the student attributes the source of this state to being called on and views his physical state as a fear response, his efficacy for answering the question is likely to decrease. In contrast, if the student attributes his body temperature and perspiring palms to the excessively hot classroom, his efficacy is less likely to be affected by his physiological state. Consequently, efficacy can be improved by reducing physical stress and interpreting physiological cues.

Measurement

Within the educational and psychological literatures, academic self-efficacy has been assessed using a variety of techniques (Bong, 2002). In the initial method of assessment, students were presented with a specific set of problems and they rated their confidence for solving each problem on a scale of 0 to 100 (e.g., Schunk, 1982; Schunk & Hanson, 1989). A second assessment method presented students with descriptions of task components reflective of a successful performance. For example, students indicated how confident they were that they could "correctly spell all words in a one-page passage"

(Shell et al., 1989). As with the first method, confidence was rated on a Likert scale. Both of these methods focused specifically on task performance. The primary difference pertained to whether the specific task was displayed or a detailed description of the task.

Additional methods of assessment were developed that were not as task specific. In some investigations, specific letter grades were used as the target performance (e.g., Zimmerman & Bandura, 1994). Students rated their confidence with respect to earning grades ranging from A to F. A more common method is for students to judge their capability to perform well in a specific domain (e.g., mathematics), often referencing general learning activities. Pintrich and DeGroot (1990) included such items on their measure, the MSLQ [e.g., "I am certain that I can understand what is taught in (a specific subject) class" and "I am certain that I can figure out how to do the most difficult schoolwork in (a specific subject)"]. Still other measures have asked students to rate their confidence to perform well in specific content areas without regard to particular tasks (i.e., domain-specific assessments) or their general academic capabilities (e.g., Pajares, 1996; Pajares & Miller, 1994).

Recently, Bong (2002) assessed the equivalence of the various forms of self-efficacy assessments in a multi-trait, multi-method investigation. Specifically, she conducted two studies assessing students' self-efficacy related to various academic domains using different assessment procedures. In the first investigation, two different methods were used to assess the efficacy beliefs of American high school students in six academic domains. For each domain, students rated their confidence to successfully complete seven representative problems. Bong also included six items from the MSLQ that addressed general learning activities within each domain (e.g., "My study skills are excellent in (a subject) class"). In the second investigation, female Korean high-school students completed measures assessing their academic efficacy for mathematics, Korean, and English. Three different measures assessed students' problem-referenced efficacy, task-referenced efficacy, and more general domain efficacy. The problem-referenced items were similar to those used in the first investigation, as were the items from the MSLQ. For the task-referenced items, students were presented with descriptions of ten tasks from each domain (e.g., Mathematics: "Solve equations containing a square root;" Korean: "Change given sentences from active to passive voice;" English: "Find parts that are grammatically incorrect for given sentences").

Analyses from the two investigations revealed that there was variation in students' responses depending on what subject matter was being assessed. Such differences across domains were expected and provided support for the specificity of students' beliefs. However, there was also evidence that students' responses differed depending on the method used to assess self-efficacy. This suggests that the various forms of assessment are not equivalent. In light of these findings, Bong (2002) recommends that researchers pay particular attention to the specificity of their efficacy measures. Pajares made a similar statement in his 1996 review of the self-efficacy literature. After reviewing numerous investigations, he found that self-efficacy was more strongly related to student outcomes when the efficacy measures are more specific to the task at hand.

Self-Efficacy in Relation to Student Learning and Achievement

Multiple studies have investigated the role of efficacy in student learning and achievement (for reviews see Pajares, 1996; Schunk, 1991). These studies indicate that self-efficacy is related to multiple aspects of the learning process including students' interest and choice of activities, effort and persistence, and emotional reactions. For instance, students with high levels of self-efficacy tend to select more difficult and challenging tasks than students with low levels of self-efficacy (Schunk, 1981; Zimmerman & Kitsantas, 1997).There is also evidence that efficacy influences students' choice of major (Hackett & Betz, 1989). Additionally, efficacious students try harder for a longer period of time than those who have less confidence in their capabilities (e.g., Multon, Brown, & Lent, 1991; Salomon, 1984; Schunk, 1981). Further, students who are more efficacious experience lower levels of anxiety with respect to academic tasks (e.g., Pajares & Kransler, 1995; Pajares & Miller, 1994) and less depression (e.g., Bandura, Barbaranelli, Caprara, & Pastorelli, 1996).

Multiple studies have also identified a relationship between students' self-efficacy and their self-regulatory processes. Specifically, efficacious students tend to set more challenging goals for themselves (e.g., Zimmerman, Bandura, & Martinez-Pons, 1992), self-monitor their progress on learning activities more effectively (e.g., Bouffard-Bouchard, Parent, & Larivee, 1991), and use strategies more often (e.g., Zimmerman & Martinez-Pons, 1990) than student who are less efficacious. Consequently, it is not surprising that self-efficacy is a significant predictor of students' academic achievement (e.g., Schunk & Ertmer, 1999; Zimmerman & Bandura, 1994).

Expectancy-Value Theory

A Historical Perspective of the Expectancy-Value Approach to Motivation

Expectancy-value theory is a specific view of motivation that was influenced by many of the early motivation theorists (e.g., Lewin, 1938; Murray, 1938) but primarily established by the work of John Atkinson (1964). While initial theories of motivation (i.e., the "grand theories") attempted explain motivation with respect to multiple settings and behaviors, Atkinson specifically focused on achievement-related behavior (Eccles et al., 1998). In his expectancy-

value model, achievement behaviors were attributed to a complex set of relations between individuals' achievement motives, expectancies for success, and incentive values (Atkinson, 1966).

Achievement motives were defined as a relatively stable dispositional need to strive for success or to avoid failure, whereas expectancies for success were defined by the expected probability for success or failure at an achievement task. Value incentives were viewed as the attractiveness of succeeding at a specific task and, according to Atkinson's model, were inversely related to expectancy for success. Atkinson developed an algebraic equation to represent the relationships among the constructs and assessed the viability of the model in multiple laboratory settings (Atkinson, 1966). Although the laboratory research offered support for Atkinson's model, it did not adequately account for achievement behavior in more realistic settings (Eccles et al., 1998).

Consequently, various expectancy-value theories have developed over the last 40 years (e.g., Battle, 1965; Crandall, 1969; Eccles et al., 1983; Feather, 1982; Wigfield & Eccles, 2000) that expanded on or revised aspects of Atkinson's model. For example, Crandall and her colleagues examined the impact of expectancies for success and task attainment value on children's achievement behaviors (e.g., Battle, 1965; Crandall, 1969; Crandall, Katkovsky, & Crandall, 1965). This work differed from Atkinson's model in several respects. For example, value was defined in terms of importance to the individual and, instead of an inverse relationship between expectancies for success and attainment values, the two constructs were positively related to one another. In another expectancy-value model, Heckhausen (1977) expanded on the expectancy construct distinguishing among four different types.

Jacquelyne Eccles, Allan Wigfield, and their colleagues (e.g., Eccles et al., 1983; Wigfield, 1994; Wigfield & Eccles, 1992, 2000) also articulated an expectancy-value model of students' academic achievement and achievement-related choices. This model was initially studied in relation to the domain of mathematics in an attempt to explain differences in mathematics achievement as well as particular enrollment patterns in high school mathematics courses (Eccles et al., 1983). Subsequent investigations explored students' expectancies, values, and achievement behaviors in a variety of domains (e.g., reading and sport) and across the elementary, middle school, and high school years. Specifically, three major longitudinal projects were conducted. In the first project, students in the fifth through twelfth grades were assessed once each year over a two year time period (Eccles et al., 1983; Eccles & Wigfield, 1995; Meece et al., 1990). The second project assessed a new sample of students in the sixth grade and then in the seventh grade after the students made the transition to junior high school (Eccles et al., 1989; Wigfield, Eccles, MacIver, Rueman, & Midgley, 1991). Finally, the third project is a 10-year longitudinal study following the development of students' expectancies and values from elementary school through high school (Eccles et al, 1993; Jacobs Lanza, Osgood, Eccles, & Wigfield, 2002; Wigfield et al., 1997).

Consequently, although there are multiple expectancy-value theories in the motivation literature, Eccles and Wigfield present what is perhaps one of the most well-articulated and well-tested expectancy-value models. Further, this model has been developed and tested within the context of formal educational environments making it applicable to students' academic achievement (e.g., Eccles et al., 1983; Eccles & Wigfield, 1995). I specifically focus on their model in my detailed discussion of expectancy-value theory and primarily concentrate on the antecedents and consequences of these constructs.

Expectancies and Values: How They Are Defined and Assessed

Similar to other expectancy-value models that were influenced by Atkinson's work, there are two main components to the Eccles and Wigfield model: individuals' expectancy for success and the values associated with the task (Wigfield & Eccles, 1992, 2000).

Expectancies for success. Students' *expectancies for success* pertain to individuals' beliefs about their ability to succeed at a current or future task (e.g., Wigfield, 1994; Wigfield & Eccles, 1992, 2000). In his work, Bandura distinguished between self-efficacy and outcome expectancy beliefs and argued that expectancy-value theorists focus on outcome expectancies. However, based on their definition of expectancy for success, Eccles and Wigfield (Wigfield & Eccles, 2000) are not assessing outcome expectancies. Outcome expectancies pertain to students' beliefs about the consequences of a specific course of action. Eccles and Wigfield focus on students' beliefs about whether they can succeed at the task. Consequently, their expectancy for success construct has more in common with Bandura's self-efficacy than with outcome expectancy beliefs (Wigfield & Eccles, 2000).

However, there are some minor differences with regard to how expectancies for success and self-efficacy are assessed in students. For instance, although expectancy for success and self-efficacy are assessed using Likert scale items, the two constructs are typically assessed at different levels of specificity. That is, expectancies for success tend to focus more on students' beliefs at the domain level (e.g., mathematics, reading, or music) whereas self-efficacy tends to be more task specific (e.g., specific problems or tasks within domains). Additionally, there are differences with respect to how individuals are asked to judge their abilities. Expectancy measures often include items that address students' self-referenced beliefs (e.g., "How well do you expect to do in math this year?") and items that require students to make comparisons across domains (e.g., mathematics vs. reading) and in relation to other students (e.g., Eccles & Wigfield, 1995). Self-efficacy items typically focus on students' beliefs about their own capabilities with respect to particular task and do not require students to make social comparisons (e.g., Pajares, 1996; Zimmerman et al., 1992).

Achievement values. Achievement value refers to how different tasks meet the varied needs of the individual (Wigfield & Eccles, 1992). Feather (1982) proposed that achievement values beliefs are stable, general beliefs that develop from society's rules as well as the psychological needs of the individual. Further, from his work, Feather concluded that there are different dimensions of values that develop from a variety of factors. Consequently, working within an academic-achievement context, Eccles and her colleagues (Eccles & Wigfield, 1995; Jacobs et al., 2002; Wigfield et al., 1997) have examined the dimensionality of students' values.

Specifically, Eccles and colleagues (Eccles, 1984; Eccles & Wigfield, 1989; Meece et al., 1990) proposed four dimensions of task value. First, *intrinsic value* refers to the enjoyment individuals experience from simply engaging in the task. The second dimension of task value, *attainment value*, pertains to the personal importance individuals place on doing well at the task. That is, how well does the task confirm or disconfirm the self perceptions? *Utility value*, the third dimension of task value, addresses the usefulness of the task in achieving future goals. Finally, *cost value* pertains to the negative aspects of engaging in the task. That is, by engaging in the task will the individual miss out on other activity that is more appealing?

Eccles and her colleagues designed items to assess students' intrinsic, attainment, and utility values (Eccles et al., 1983; Eccles & Wigfield, 1995). Similar to expectancies for success, values are typically assessed at the domain level and students are asked to make some cross-domain comparisons (e.g., "Compared to most of your other activities, how important is it for you to be good at math?). However, social comparisons are not used in the value items. Empirical studies have confirmed that the intrinsic value, attainment value, and utility value dimensions differentiate from one another (e.g., Eccles & Wigfield, 1995; Wigfield et al., 1991). Cost values were not assessed in the work by Eccles and colleagues, but there is evidence that cost value differentiates from the other dimensions of value in college age women (Battle & Wigfield, 2003).

<u>Sources of Expectancies and Achievement Values</u>

In addition to differentiating the various aspects and dimensions of students' competency beliefs and achievement values, Eccles, Wigfield, and colleagues (e.g., Eccles et al., 1983; Eccles et al., 1998; Wigfield & Eccles, 1992) proposed and tested an elaborate model depicting how students' expectancies for success and values arise from a complex set of psychological and social factors. For instance, external factors, such as the roles and values imposed by the specific culture and the beliefs and behaviors of socializers (e.g., parents) impact the child's perceptions of the environment, as well as self beliefs and goals. Due to its complexity, the full model has not been assessed in a single investigation. Instead, various portions of the model have been examined. I discuss relevant findings from these investigations.

Ability beliefs. Eccles and Wigfield (e.g., Eccles et al., 1983; Wigfield & Eccles, 1992) focus on ability beliefs as one aspect of students' self-beliefs that may contribute to expectancies for success and values. Specifically, *ability beliefs* are defined as students' beliefs about their current competence at a given task (Wigfield & Eccles, 2000), and they are viewed as conceptually distinct from expectancies for success. Ability beliefs pertain to students' beliefs about their present competencies, whereas expectancies for success are related to students' beliefs with regard to future successful performances. However, despite the conceptual distinction, ability beliefs and students' expectancies for success do not differentiate empirically (Eccles & Wigfield, 1995). To test this relationship, Eccles and Wigfield (1995) used data obtained from students in the fifth through the eleventh grades (Year 1). They also used data assessed in the following year when students were in the sixth through twelfth grades (Year 2). Employing exploratory and confirmatory factor analytic techniques on the Year 1 data, the researchers found that expectancy for success items and ability items loaded on the same factor. This factor structure was confirmed with the Year 2 data.

Although expectancies for success did not differentiate from ability beliefs when both constructs were assessed at the same time, in another investigation, Meece et al. (1990) modeled the longitudinal effects of ability beliefs and past academic performance (i.e., grades) on students' expectancies, importance (i.e., attainment) value, anxiety, intentions, and academic performance within the domain of mathematics. Data were used from when students were in the sixth through eighth grades (Year 1) and then a year later in the seventh through ninth grades (Year 2). In the first model, Year 1 ability beliefs significantly and positively predicted expectancies for success and ratings of the importance of mathematics and negatively predicted math anxiety. Further, although Year 1 grades and ability beliefs were significantly related to one another, grades were not significantly related to the other variables in the model.

A second model was also tested incorporating Year 2 grades and students' intentions to take additional mathematics courses after Year 2. Year 1 ability beliefs again predicted Year 2 expectancies for success, ratings of the importance of mathematics, and math anxiety. Year 2 grades were significantly predicted by Year 1 grades and by Year 2 expectancies for success. These relationships are interesting for several reasons. First, it appears that the effects of students' ability beliefs on their subsequent academic performance were mediated by expectancies for success. Second, Year 2 expectancies had a stronger effect on Year 2 grades than Year 1 grades. Finally, although Year 1 grades were again correlated with Year 1 ability beliefs and they significantly predicted Year 2 grades, they were not significantly related to any of the other variables in the model. These findings highlight the role of students' ability beliefs, as well as their expectancies for success with regard to academic performance (Meece et al., 1990).

Task difficulty. Within their model, Eccles and Wigfield also specify perceptions of task demands as one of the factors contributing to students’ expectancies for success and achievement values (Wigfield & Eccles, 2000). In the first major project, Eccles and her colleagues (Eccles et al., 1983) operationalized this construct as task difficulty. Although Eccles et al. (1983) viewed students' beliefs about their abilities as a stronger predictor of expectancies, they also believed that students' perceptions of task difficulty may, over time, negatively impact students' ability beliefs and subsequent expectancies for success, achievement, and choices. They also hypothesized that the students' ability beliefs would mediate the impact of task difficulty perceptions on students' achievement values (Eccles & Wigfield, 1995).

Eccles and Wigfield examined the structure of students' task difficulty beliefs with regard to mathematics in their 1995 study. Exploratory and confirmatory analyses were conducted with items assessing students' ability/expectancy beliefs, task values, and task difficulty perceptions. Exploratory factor analyses suggested two task difficulty factors and confirmatory models of the Year 1 and Year 2 data supported this factor solution. The first factor pertained to students' perceptions of the difficulty of the subject matter (e.g., "In general, how hard is math for you?" and "Compared to most other school subjects that you take, how hard is math for you?"). The second factor represented students' beliefs about the effort required to do well (e.g., "How hard do you have to try to get good grades in math?" and "How hard would you have to try to do well in an advanced high school math course?"). As predicted, the task difficulty factors were negatively related to students' ability/expectancy beliefs and their task values. Further, task difficulty was more strongly related to ability/expectancy beliefs than to task values.

Eccles et al. (1983) included task difficulty in path analyses used to assess their proposed model. As part of the model, they examined the possible antecedents of task difficulty, as well as the impact of task difficulty on students' ability beliefs, expectancies, task values, and expected performance. Analyses indicated that students' perception of task difficulty was significantly predicted by their previous performance in math class, their perceptions of parents' and teachers' perception of task difficulty, and their perceptions of parents' and teachers' beliefs about their ability. Further, task difficulty assessed in Year 1 negatively predicted a number of variables assessed in Year 2, including students' expectancy and ability beliefs, their estimated performance in math, their interest in and liking for math, and their perceptions of parents' and teachers' beliefs about students' ability. Based on these findings, students' perceptions of task difficulty contributes to their achievement behavior.

Beliefs of parents and teachers. Eccles' and Wigfield's (Eccles et al., 1983) model also suggests that the beliefs and behaviors of parents and teachers, as they are perceived by students, influence students' beliefs about themselves, and, in turn, affect achievement and choices. Data analyzed in various investigations support these proposed relationships (e.g., Eccles, 1993; Eccles et al., 1983). For instance, multiple investigations have demonstrated that parents' beliefs about their children's abilities are significantly related to the children's perceived competency ratings (e.g., Frome & Eccles, 1998; Jacobs & Eccles, 1992; Wigfield et al., 1997). Teachers' beliefs about students' abilities were also significantly related to children's beliefs (Wigfield et al., 1997). Further, the relationship between parents' and teachers' beliefs and students' beliefs about their competencies became stronger as the students grew older (Wigfield et al., 1997).

Additionally, although most investigations focused on mothers' beliefs, Fredericks and Eccles (2002) used data from both mothers and fathers with respect to their beliefs about their children's competency in mathematics and sports. Parents’ beliefs were associated with children's perceptions of their own competence and that relationship was stronger for sports than for mathematics. In particular, fathers' beliefs about their children's competencies in sports were strongly related to the students' perceived competency and valuing of sports.

The Impact of Expectancies for Success and Achievement Values on Achievement Behaviors

In addition to the possible antecedents to students' expectancies and values, Eccles, Wigfield, and their colleagues (e.g., Eccles et al., 1983; Eccles & Harold, 1991; Meece et al., 1990) have also explored the predictive power of these constructs. For example, they examined the influence of expectancies for success and achievement values on students' academic achievement and academic choices (Eccles et al., 1983; Meece et al., 1990). Specifically, in the model tested by Meece et al. (1990), students' math ability beliefs and math grades from Year 1 were used to predict students' expectancies for success, ratings of importance and math anxiety, final math grades in Year 2 as well as students' intentions to take additional mathematics classes, as assessed in Year 2. Additionally, direct paths from Year 2 expectancies, values (i.e., importance), and anxiety to Year 2 grades and intention were also tested.

Entering grades from Year 1 provided a means to control for students' prior achievement. Indeed, as previously noted, Year 1 grades significantly predicted Year 2 grades. However, there was an even stronger relationship between Year 2 expectancies for success and Year 2 grades. Further, students' ratings of the importance of mathematics at Year 2 significantly predicted their intentions to take additional mathematics classes (Meece et al., 1990). Consequently, expectancies for success predict individuals' task performance, whereas achievement values relate more to choice of task or activity (Eccles et al., 1983; Meece et al., 1990).

Developmental Changes in Expectancies and Values

Finally, in discussing the Eccles and Wigfield (E.g., Eccles et al., 1983) expectancy-value model, I would be remiss if I did not mention their work with regard to the development of students' expectancies for success and achievement values. Understanding the developmental changes in students' beliefs and values is indeed important and a great deal of attention has been devoted to this issue (e.g., Eccles et al., 1993; Jacobs et al., 2002; Wigfield et al., 1997). However, for the purpose of this review, I briefly summarize the major findings with regard to changes as well as the consistencies in students' beliefs and values.

Level of specificity. First, students display a similar level of specificity with regard to their ability/expectancy beliefs and values from elementary school through high school (e.g., Eccles et al., 1993; Eccles & Wigfield, 1995). That is, the measures developed by Eccles and her colleagues (e.g., Eccles et al., 1983; Eccles et al., 1993; Eccles & Wigfield, 1995) addressed students' beliefs and values within specific domains (e.g., mathematics, reading, sports, and music). As early as the first grade, students differentiate among the various domains. Specifically, factor analyses indicated that items related to the same domains loaded together (Eccles et al., 1993). Further, students displayed different levels of expectancies for success and values depending on the domain (Wigfield & Eccles, 1994; Wigfield et al., 1997).

Differentiation of expectancies and values. Second, developmental patterns were identified with regard to how the proposed constructs are manifested in students. Given the two key components in the model, expectancy for success and value, it is important to note that separate competency and value factors have been identified at all grade levels including the first grade (e.g., Eccles et al., 1993). This upholds the model and supports the distinction between what students believe they can achieve and the reasons why they want to achieve.

Additionally, Eccles, Wigfield, and colleagues (e.g., Meece et al., 1990) found that the dimensions of value develop separately in the individual and predict different outcomes. For example, the degree to which younger students value and choose tasks is related to the intrinsic value of the task (Wigfield & Eccles, 1992). As children develop and progress through school, their level of intrinsic value tends to decrease and their choices incorporate those tasks that are valued by the adults in their environment. These values are gradually internalized by the individual to represent the attainment value dimension. Additionally, with age and experience, students begin to realize how certain tasks will be more useful in attaining their future goals and thus, the utility aspect of value begins to emerge and stabilize. Differences in how students value different domains and activities are apparent as the components of value development and differentiate over time (Wigfield et al., 1991).

<u>Levels of expectancies and values.</u> Third, as students develop there are changes with regard to how they rate their abilities and expectancies for success, as well as how much they value various activities (e.g., Wigfield & Eccles, 1992; Wigfield et al., 1991; Wigfield et al., 1997). With regard to students' ability and expectancy beliefs, data from multiple investigations indicate that students' beliefs about their abilities tend to decrease as they grow older and progress through school. This pattern is evident from elementary

school through high school across different domains (Eccles et al., 1993; Jacobs et al., 2002; Wigfield et al., 1997). Further, the decline in students' competency beliefs varies by domain (Wigfield et al., 1997; Wigfield et al., 1991). For example, Jacobs et al. (2002) found that students' beliefs about their competencies in language arts declined rapidly in elementary school but leveled off or increased in later years. In contrast, students' competencies in sport declined rapidly throughout high school.

There are also significant changes in students' achievement values over time (Jacobs et al., 2002; Wigfield et al., 1997; Wigfield et al., 1991; Wigfeld & Eccles, 1992). Although most of the reported findings indicate that younger students value various academic domains more than older students (Eccles et al., 1993; Wigfield et al., 1997), the nature of these differences, as well as developmental changes, tend to vary depending on the age of the student and the domain under consideration (Jacobs et al., 2002; Wigfield et al., 1991). For instance, in a longitudinal study Wigfield et al. (1997) found that students' beliefs about the utility and importance of mathematics, reading, instrumental music, and sports declined over the course of three years. Students' intrinsic interest in reading and music also declined but their interest in math and sports remained relatively constant. Other findings suggest that while students view math as less important as they get older, their valuing of English increases with age (Eccles et al., 1983; Eccles et al., 1989; Wigfield, 1994; Wigfield et al., 1991). These variations in students' values underscore the importance of distinguishing between the various dimensions of value and assessing value at a domain-specific level (Wigfield & Eccles, 2000).

Summary and Salient Gaps in the Eccles and Wigfield Expectancy-Value Model

Within the expectancy-value tradition, the model proposed by Eccles, Wigfield, and their colleagues (Eccles et al., 1983; Wigfield & Eccles, 2000) has emerged as one of the more prominent models in the literature. The central constructs in the model, expectancies for success and achievement values, have been carefully defined and discussed in relation to other constructs in the motivation literature (e.g., self-efficacy). The conceptual distinctions among the various aspects of the model have also been empirically assessed (e.g., ability beliefs vs. expectancies for success and the different dimensions of value; Eccles & Wigfield, 1995), and the development of these constructs in students over the elementary, middle-school, and high school years has been examined (e.g., Eccles et al., 1993; Jacobs et al., 2002). Further, portions of the model depicting the antecedents of students' expectancies and values have been explored (e.g., Eccles et al., 1983; Meece et al., 1990). For instance, ability beliefs and perceptions of task difficulty appear to influence students' expectancies and values. Additionally, students' expectancies and values are significantly related to subsequent academic achievement and choices (e.g., Meece et al., 1990).

However, in examining this extensive collection of works, several gaps and areas for future research are apparent. First, Eccles and her colleagues (Eccles et al., 1983; Jacobs et al., 2002; Wigfield et al., 1997; Wigfield & Eccles, 1994) have focused primarily on students in elementary school through high school. Indeed, understanding the changes that occur in these formative years is a major undertaking. However, valuable insights into students' development and achievement may also be gained by extending these investigations beyond secondary education. In particular, the expectancy-value model may explain students' achievement in college as well as their choice of classes, major, and subsequent career (e.g., Battle & Wigfield, 2003). Although some studies have used the Eccles and Wigfield (Eccles et al., 1983) model with college samples (Battle & Wigfield, 2003; Enman & Lupart, 2000), additional research is needed to fully examine the complex relationships specified in the Eccles and Wigfield model.

Second, Eccles and Wigfield (e.g., Eccles et al., 1983; Wigfield & Eccles, 1992) proposed four aspects of achievement values, but primarily focused on intrinsic value, attainment value, and utility value. The antecedents and consequences of cost value, as well as how cost interacts with the other dimensions of value, is a relatively unexplored topic. In one study with college women, Battle and Wigfield (2003) developed a new measure, the *Value of Education* scale (VOE), in order to investigate cost values and other dimensions of achievement values in relation to the pursuit of a graduate school education. The value factors they identified, intrinsic-attainment, utility, and cost, significantly predicted women's intentions to attend graduate school. However, intrinsic-attainment value explained considerably more of the variance in students' intentions than cost value. Additional work is needed to more fully understand the nature and function of cost value, as well as the other dimensions of achievement value, in varied contexts.

Third, given the association between students' expectancies for success and their actual performance, as well as the link between students' values and their subsequent choices (e.g., Meece et al., 1990), it is important to understand the factors that impact students' beliefs and values. Eccles and Wigfield proposed a model for the sources of expectancies and values and have assessed different aspects of the model. This is certainly a start but each investigation raised more questions and left others unanswered.

For example, ability beliefs and perceptions of task difficulty were identified as significant predictors of students' beliefs and values. Although Eccles et al. (1983) identified some sources of students' task difficulty beliefs (e.g., past performance and parents' perceptions), are there other factors (e.g., epistemological beliefs) that contribute to students' perceptions of task demands? Further, are ability beliefs based solely on past performance? How are ability beliefs formed with regard to tasks students have not experienced before? Perhaps future research can explore such questions.

Motivation and Epistemological Beliefs

In the preceding sections, I discussed the state of the epistemological belief literature and overviewed three prominent views of achievement motivation. With respect to the epistemological beliefs literature, I traced the study of students' beliefs about knowledge to its roots in the philosophical and psychological literatures and described how students' knowledge beliefs are conceptualized and assessed in recent research. I also discussed the relationships between epistemological beliefs, learner characteristics, learning environments, and various learning and cognitive outcomes. Based on this review of the epistemological belief literature, I identified the general trends and gaps, including the paucity of research examining the relationship between students' epistemological beliefs and achievement motivation.

Next, I discussed three views of achievement motivation (i.e., goal orientations, self-efficacy, and expectancy-value theory). For each approach to motivation, I defined the central constructs, discussed how they are assessed, and highlighted their role in the learning process. Further, I addressed the factors believed to contribute to students' goal orientations, self-efficacy and expectancies, and achievement values. Based on this overview, specific links between students' epistemological beliefs and achievement motivations are evident. In particular, it appears that students' beliefs about knowledge may be one of the factors that contribute to their achievement motivations. I highlight these potential connections and discuss the few empirical findings that indicate students' epistemological beliefs are related to their achievement motivations.

Theoretical and Empirical Support

Epistemological Beliefs and Goal Orientations

Within the motivation literature, students' goal orientations are attributed to multiple sources. Dweck and Leggettt (1988) proposed that students' goals are determined by their belief systems. Ames (1992) suggested that students' goals are influenced by the goal structure of their environment. Nicholls (1984) held that characteristics of both the individuals and the environment influenced students' goals. Multiple studies have examined the role of environmental factors on students' goal orientations (e.g., Ames, 1992). In particular, a large-scale project was conducted exploring the changes in students' goals and achievement after radical changes were made to the structure and organization of an elementary and middle school (Maehr & Midgely, 1996). Based on this work, recommendations have been made as to how educators can create environments that foster mastery goal orientations (Maehr & Midgely, 1991).

However, fewer studies have explored the impact of students' belief systems on their goal orientations. Those studies that have been conducted typically focused on students' beliefs about intelligence. For example, Dweck and her colleagues (1982) found that students' beliefs about intelligence affect their choice of learning or performance goals. Students who were manipulated to believe that intelligence was fixed tended to adopt more performance goals. Students who were led to believe that intelligence could be increased tended to adopted learning goals.

In addition to beliefs about intelligence, students' beliefs about knowledge may also influence their goal orientations. There is theoretical and empirical support for this proposition. For instance, as previously noted, Schommer-Aikins' epistemological belief dimensions of Quick Learning and Innate Ability were based, in part, on Dweck's work with intelligence beliefs (Schommer, 1990). Consequently, one would expect these aspects of students' knowledge beliefs to be similarly related to students' goal orientations. The other dimensions of students' knowledge beliefs may also relate to the types of goals students choose to pursue.

In their study with gifted students in the fourth, fifth, and sixth grade, Neber and Schommer-Aikins (2002) found that a belief in fixed ability was related to lower levels of task goals. Similarly, students' who held that success does not require hard work also tended to endorse task goals less than students who believed in the need for hard work and effort to succeed. In another investigation, college students' beliefs with respect to Quick Learning and Fixed Ability were negatively related to intrinsic goals (Paulsen & Feldman, 1999).

Further, significant relationships between other aspects of students' epistemological beliefs (e.g., beliefs about the structure of knowledge) are evident in the literature. For example, Paulsen and Feldman (1999) found that students' belief about simplicity of knowledge were positively related to extrinsic goals and negatively related to intrinsic goals. Students who viewed knowledge as more simplistic and isolated tended to achieve in order to receive external praise and rewards, whereas students who viewed knowledge as complex and interrelated engaged in tasks in order to satisfy their own interests and desires. When Hofer (1999) examined students' beliefs about mathematics knowledge and their intrinsic goal orientation, she also identified a significant correlation. Specifically, the less students believed mathematics was an isolated activity, the more they tended to have an intrinsic goal orientation. Additionally, Qian and Burrus (1996) found that high-school students' beliefs about the speed of learning, the certainty/simplicity of knowledge, and the innateness of ability significantly predicted students' goal orientation with students' knowledge beliefs, explaining approximately 12% of the variance in goal orientations.

However, these investigations primarily examined correlations between students' beliefs and goal orientations. Consequently, it is difficult to determine if beliefs are the source of students' goals, if students' goals influence their knowledge beliefs, or knowledge beliefs and goal orientations are related due to an external third variable. Additional research is needed to determine the nature of the relationship between students' epistemological beliefs and goal orientations.

Epistemological Beliefs and Competency Beliefs

Self-efficacy and expectancies for success both address students' beliefs about their competencies. Although there are some differences with regard to how they are assessed, both are attributed to similar sources (e.g., prior experience). I chose to group them together under the heading of competency beliefs.

According to Bandura (1997), self-efficacy is based on information from students' prior mastery experiences, vicarious experiences, verbal persuasion, and physiological response. Additionally, Eccles and Wigfield (e.g., Eccles et al., 1983; Wigfield & Eccles, 2000) proposed that students' expectancies for success are influenced by their goals and general self-schemata that include students' beliefs about their abilities and their perceptions of the task demands. Students' epistemological beliefs are an aspect of students' perception of the learning task that have not been explored extensively in relation to their competency beliefs. However, students' judgments about their abilities to succeed at a learning task are likely to be based, in part, on their conceptions or misconceptions of knowledge and its acquisition. As they form their efficacy and expectancies, students may compare their conceptions of what knowledge is and what is needed to do well in acquiring that knowledge against their perceptions of their own abilities.

Empirical evidence suggests that there is a relationship between students' beliefs about knowledge and their competency beliefs (e.g., Hofer, 1999; Paulsen & Feldman, 1999). For instance, both Paulsen and Feldman (1999) and Neber and Schommer-Aikins (2002) assessed students' epistemological beliefs using the SEQ and their self-efficacy using the MSLQ. Paulsen and Felman (1999) administered the measures to college students and found that self-efficacy was negatively correlated with the Simple Knowledge and Fixed Ability belief factors. In contrast, Neber and Schommer-Aikins (2002) assessed the knowledge beliefs and science self-efficacy of students in the fourth, fifth, and sixth grades. Using path analysis, they found that believing success is unrelated to hard work negatively predicted students' science self-efficacy. Students' beliefs about the simplicity of knowledge were negatively related to self-efficacy.

In another investigation, Hofer (1999) assessed students' epistemological beliefs relative to mathematics using a series of items that she developed and examined these beliefs in relation to self-efficacy in mathematics, as assessed by the MSLQ. She found that students' who believed mathematics knowledge existed in isolation tended to have lower levels of mathematics efficacy. These investigations indicate that students with epistemological beliefs that are considered to be less mature or sophisticated, also tend to have lower levels of self-efficacy.

Epistemological Beliefs and Achievement Values

Finally, in the Eccles and Wigfield model (Wigfield & Eccles, 2000), students' achievement values are influenced by their goals and general self-schemata (e.g., ability beliefs and task demands) as well as their affective memories. Students' epistemological beliefs may serve as a foundation upon which students base their judgements as to the difficulty of tasks. Additionally, in forming their affective memories, students may attribute their experiences to the nature of knowledge they encounter. Thus, students' epistemological beliefs may impact the various aspect of achievement value.

In my search of the literature, I found very few studies that explicitly examined the relationships between epistemological beliefs and achievement values and none that assessed various dimensions of value proposed by Eccles and Wigfield. For instance, in their study with college students, Paulsen and Feldman (1999) found that students' task values were negatively correlated with Quick Learning and Fixed Ability belief factors. Neber and Schommer-Aikins (2002) also found a negative relationship between students' valuing of science and their beliefs that the need for effort does not relate to hard work.

Thus, it appears that students value academic tasks less if they believe their ability to learn is fixed and if they believe learning occurs quickly with little effort.

Additionally, I encountered a study by Enman and Lupart (2000) that explored factors underlying college students' selection of science majors. Specifically, students completed Schommer-Aikins' epistemological questionnaire and an adaptive version of the Eccles et al. scales (1983) and indicated their major and favorite subject. However, Enman and Lupart (2000) did not examine epistemological beliefs and the expectancy-value constructs in relation to one another. Instead, they used these variables to predict students' endorsement of science as a favorite subject and their choice of science as a major. Analysis of these data revealed that the Fixed Ability belief factor was a significant predictor of students majoring in science and selecting science as their favorite subject. If selecting science as a favorite subject is viewed as a proxy for intrinsic interest, this study supports the hypothesis that epistemological beliefs are related to value. However, more conceptual and empirical work needs to be done in this area.

Issues for Further Research

The purpose of this review was to provide a framework for exploring students' epistemological beliefs in relation to their achievement motivation. Specifically, epistemological beliefs were discussed and three current views of motivation (i.e., goal orientations, self-efficacy, and expectancy-value theory) were presented. However, as evidenced in the section examining the relationships between students' epistemological beliefs and motivation, little empirical work has explored these constructs in relation to one another. Based on this review, the following areas are viewed as areas for future research: clarifying what we mean by epistemological beliefs, exploring the nature of epistemological and motivational constructs in varied populations, and examining the relationships between knowledge beliefs and motivation.

CHAPTER III

METHODOLOGY

In this chapter, the pilot study, sample, measures, and tasks are described. Additionally, the procedures used to conduct the study, as well as the data analysis plan, are discussed.

Pilot Study

Purpose

Before collecting data for the current investigation, I conducted a pilot study with a sample of comparable students. The purpose of the pilot study was two-fold. First, I wanted to determine the amount of time students needed to complete the measures. Given the number of measures and tasks I was concerned that the amount of time needed to complete the materials may have been unreasonable. Second, I wanted to examine the performance of the knowledge test items. The texts used in the investigation and the corresponding knowledge tests were created for the current investigation. I wanted to ensure that the knowledge test items functioned as expected. For instance, I anticipated that students would perform better on the post-reading test than on the pre-reading test. Further, using the pilot data, I was able to examine the item difficulty and discrimination, distractors appropriateness, and reliability data for the knowledge test items at pre-reading and post-reading.

Participants

Twenty-four university undergraduates participated in the pilot study. The students were enrolled in an educational psychology class at a large, land-grant institution in the mid-Atlantic United States. The students, 6 male (25%) and 18 female (75%), were primarily juniors and seniors in college (i.e., 58.4%) and had an average age of 21.4 years. Additionally, 66.7% of the students were Caucasian with the remaining 33.3% consisting of 20.8% Asian, 4.2% Hispanic, and 8.3% multi-racial. Similar percentages with respect to gender and ethnicity were expected in the sample for the current investigation. However, I anticipated that the sample for the full investigation would include individuals from additional ethnic groups (e.g., African-American and American Indian).

The majority of the students in the pilot study sample had the expected level of prior experience with respect to history and mathematics. Specifically, most students had completed three to four history and mathematics courses in high school and one or two such courses in college. However, the students had more experience with statistics than anticipated. That is, 50.0% of the students (i.e., 12 students) had previously taken one college-level statistics course and 29.2% (i.e., seven students) had previously taken two college-level statistics courses. The extent of students' previous exposure was of concern due to the statistical content of the mathematics portion of the text and the mathematics knowledge test. I wanted to ensure that students had the opportunity to learn new information from the text. Consequently, in my analysis of the pilot data, I also analyzed whether students’ previous experience with respect to mathematics and statistics was significantly related to their mathematics knowledge test performance.

Measures

The materials administered to the students in the pilot study are the same materials used in the proposed study. The measures and tasks are described in detail in the Method section for the main investigation. A brief description is offered here.

Students completed measures of their epistemological beliefs, ability beliefs, expectancies for success, achievement values, and intentions to engage in behaviors related to history and mathematics. These measures involved a series of items to which students responded using a 10-point scale. Students also read a two-part text containing a segment dealing with history and a segment dealing with mathematics and completed strategy inventories after reading each section of the text. There were separate knowledge tests for the history and mathematics segments of text and the same items were presented at pre-reading and post-reading. Each test contained 15 multiple-choice questions, with four possible responses. The procedures employed to develop suitable items are described later in this chapter.

Procedure

Students completed the materials independently in a group setting. First, they completed the consent form. Second, they responded to the pre-reading knowledge measures, counterbalanced by domain. Third, students completed the epistemological belief, motivation, and intentions measures in counterbalanced order. Fourth, students read the two-part text and completed strategy inventories after reading each section of text. Fifth, students provided requested background information (e.g., age and gender), and then responded to the post-knowledge measures to determine what they learned from the text.

Results

The purposes of the pilot study were to determine a) the amount of time students needed to complete the measures and b) suitability of the knowledge test items. I conducted an item analysis of the knowledge test items and examined the reliability of data from the knowledge tests at pre-reading and post-reading. Additionally, given students' previous exposure to statistics, I analyzed the relations between the previous mathematics and statistics experience and performance on the mathematics test.

Time to Complete the Measures

To ascertain completion time, I recorded the time students started the experimental tasks and when the materials were turned in to me. Most students completed the packet within 30-45 minutes, with a modal time of 40 minutes. Exceptions to this included one student who finished in 20 minutes and three students who took up to one hour to complete the measures. Based on these findings, I felt that the time students needed to complete the measures was reasonable.

Relations Between Previous Mathematics and Statistics Experience and Mathematics Test Performance

Before conducting an item analysis, I examined students' performance on the pre-reading and post-reading mathematics test, as well as the change in their knowledge score from pre-reading to post-reading, in relation to the number of college mathematics and statistics courses students completed. As seen in Table 3 the correlations between the number of mathematics and statistics courses students completed tended to be non-significant. The one exception to this was a significant positive relation between the number of statistics courses and performance on the post-reading mathematics knowledge test. However, there was not a significant relation between the change in students' knowledge scores from pre-reading to post-reading by the number of statistics classes they had taken in college.

Table 3

Correlations Between Mathematics and Statistics Experiences and Mathematics Test Performance for the Pilot Data (n = 24)

Variable	1.	2.	3.	4.	5.
1. Number of College Mathematics Courses	---				
2. Number of College Statistics Courses	.123	---			
3. Pre-Reading Mathematics Knowledge Score	-.055	.305	---		
4. Post-Reading Mathematics Knowledge Score	.067	.497*	.567**	---	
5. Mathematics Knowledge Change Scores	.161	.353			---

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

These findings indicated that the number of college mathematics and statistics course students completed (i.e., a proxy variable for prior knowledge) was not related to their pre-reading knowledge or the change in their knowledge score from pre-reading to post-reading. Due to the significant finding with respect to statistics courses and post-reading knowledge scores, I intended to examine potential relations between test performance and prior experience for the sample used in the full investigation.

Item Analysis

Item difficulty. Item difficulty is one of the most often used parameters for describing items on dichotomously scores tests (Crocker & Algina, 1986). For dichotomously scores items, like those on the knowledge tests, item difficulty represents the proportion of students who provided a correct response to the item. A difficulty level of .50 is considered optimal because it maximizes the total test score variance. However, multiple-choice aptitude and achievement tests often have item difficulties ranging from .60 to .80 (Crocker & Algina, 1986). Multiple-choice items have higher difficulty levels (i.e., are easier items) due to the opportunity for students to guess the correct answer.

I analyzed the item difficulties for the history and mathematics pre-reading and post-reading knowledge tests (Tables 4 and 5). For the pre-reading history test, items ranged in difficulty from .21 to .79 with an average item difficulty of .54 (Table 4). At post-reading the items on the history tests ranged in difficulty from .42 to .83, with an average item difficulty of .70. Although the item difficulty levels were somewhat low on the pre-reading knowledge test, this was expected. At pre-reading, students presumably did not know much of the information. In contrast, at post-reading, the item difficulties were higher and quite similar to the item difficulties of published tests. Thus, I viewed level of difficulty of the history knowledge items as appropriate for this investigation.

As seen in Table 5, the mathematics knowledge items displayed a similar pattern with respect to item difficulty. That is, the items had lower difficulty levels (i.e., were harder) at pre-reading than at post-reading. Specifically, at pre-reading, the mathematics

Table 4

Item Statistics for the Pre-Reading and Post-Reading History Knowledge Tests

	Pre-Reading		Post-Reading	
Item	Difficulty	Discrimination	Difficulty	Discrimination
1	0.25	0.10	0.88	0.33
2	0.50	-0.31	0.58	0.78
3	0.71	0.28	0.79	0.44
4	0.38	0.43	0.62	0.43
5	0.79	-0.21	0.75	-0.04
6	0.75	0.62	0.83	0.44
7	0.75	0.39	0.75	-0.03
8	0.75	0.26	0.79	0.21
9	0.54	0.40	0.58	0.31
10	0.50	0.40	0.62	0.78
11	0.58	0.40	0.75	0.56
12	0.46	0.07	0.79	0.21
13	0.50	0.06	0.62	0.42
14	0.21	0.08	0.42	0.76
15	0.42	0.31	0.71	0.55

Table 5

Item Statistics for the Pre-Reading and Post-Reading Mathematics Knowledge Tests

	Pre-Reading		Post-Reading	
Item	Difficulty	Discrimination	Difficulty	Discrimination
1	0.17	0.13	0.79	0.03
2	0.08	-0.18	0.46	0.53
3	0.71	0.55	0.83	0.50
4	0.42	0.48	0.58	0.38
5	0.42	0.28	0.25	0.19
6	0.54	0.53	0.38	0.54
7	0.71	0.43	0.75	0.39
8	0.42	0.28	0.62	0.51
9	0.58	0.32	0.50	0.54
10	0.17	0.24	0.54	0.31
11	0.46	0.30	0.62	0.64
12	0.71	0.43	0.75	0.51
13	0.50	0.10	0.67	0.28
14	0.33	0.55	0.29	0.32
15	0.46	0.60	0.46	0.90

knowledge test items ranged in difficulty from .08 to .70, with an average difficulty of .44. For the post-reading test, the items ranged in difficulty from .25 to .83 with an average difficulty level of .56.

Based on the item difficulty parameter, the mathematics test appeared to be harder for students than the history test. This difference may be attributable to differences in students' background knowledge and skills. Additionally, for students to acquire new mathematical knowledge, they may need additional time and different types of tasks (e.g., practicing problems) than for the same students to acquire new historical knowledge. However, because the analyses for the history and mathematics data were to be conducted separately, I did not view this as a problem.

Item discrimination. Another parameter typically used to describe the performance of test items is item discrimination. Item discrimination indicates how an item differentiates between individuals considered to be low or high on a relevant criterion (e.g., ability or test performance). The index of discrimination is a discrimination parameter that is appropriate for dichotomously scored items. To calculate the index of discrimination, students must be split into high-performing and low-performing groups. For each item, the proportion of students from the low-performing group who answered the item correctly is subtracted from the proportion of students from the high-performing group who answered the item correctly (i.e., $D = p_L - p_H$). Consequently, the index of discrimination can range from -1.00 to +1.00. Positive values indicate that the high-performing students get the item correct more often than the low-performing students. In contrast, negative values indicate that low-performing students tend to get the item correct more often than high-performing students.

Further, Ebel (1965) provides guidelines for interpreting the index of discrimination when the total test score is used as the criteria for forming groups. Specifically, if the index of discrimination term is greater than .4 the item is considered to be functioning satisfactorily. Items with an index of discrimination between .30 to .39 need little or no revision (Ebel, 1965). Ebel (1965) recommends that items with an index of discrimination less than .30 should be revised or eliminated.

To create the low-performing and high-performing groups, I used students' total test performance as the criteria. The students in the upper third of test performance were classified as high-performing and students who scored in the bottom third were classified as low-performing students. These groups were created separately for the pre-reading and post-reading history and mathematics tests and the index of discrimination was calculated for each item (Tables 4 and 5).

Because students were not expected to perform well on the pre-reading knowledge measures, I did not expect the items to be highly discriminatory at pre-reading. This is reflected in the index of discrimination values for the pre-reading knowledge test items (Tables 4 and 5). That is, at pre-reading only six history items and nine mathematics items had an index of discrimination over .30. However, at post-reading, most of the items on the history and mathematics knowledge tests had an index of discrimination greater than .30 (i.e., 11 and 12 items for history and mathematics, respectively). I examined those items with an index of discrimination less than .30. However, I decided to retain these items in their original form due to content coverage considerations.

Distractor analysis. As part of my item analysis, I also examined how well the distractors functioned. I wanted to know if students were inclined to choose the distractors over the correct answer and if all of the distractors were viable. For each item on the history and mathematics pre-reading and post-reading test, I examined the frequency with which each option (i.e., correct response and distractors) was selected. I anticipated that the distractors would be selected more often on the pre-reading measures than on the post-reading measures. Further, I expected that at post-reading fewer distractors would appear appropriate to students than at pre-reading.

These expectations were upheld by the pilot study data. For the pre-reading history and mathematics knowledge tests, all of the options (i.e., a, b, c, and d) were selected by one or more student for 11 of the items. For the remaining four items on each test, students regularly selected at least one distractor in addition to the correct response. For the post-reading knowledge tests, all of the multiple-choice options were selected by at least one student for 10 of the history items and 8 of the mathematics items. The remaining five and seven items for history and mathematics, respectively, had at least one distractor that was selected in addition to the correct response. These results indicate that the distractors were functioning appropriately.

Total test means and variances. The information presented thus far pertained to the performance of the individual test items. However, information from these items can also be used to derive the total test mean and variance. That is, the total test mean is the equal to the sum of the individual item difficulties. The total test variance is also a function to the item difficulties. The means, variances, and standard deviations for the pre-reading and post-reading history and mathematics tests are presented in Table 6.

Table 6

Means, Variances, Standard Deviations, and Reliabilities for the Pre-Reading and Post-Reading History and Mathematics Knowledge Tests

	History		Mathematics	
Statistic	Pre-Reading	Post-Reading	Pre-Reading	Post-Reading
Mean	8.08	10.50	6.67	8.50
Variance	2.77	9.22	6.32	9.30
Standard Deviation	1.67	3.04	2.51	3.05
Reliability (α)	-.24	.71	.51	.68

As expected, students performed better on the knowledge tests after reading the texts. Additionally, the increase in students' knowledge score from pre-reading to post-reading was statistically significant for both history [t (23) = 4.73, p< .05] and mathematics [t (23) = 4.24, p< .05]. The history and mathematics also appeared to have sufficient variance at pre-reading and post-reading.

Reliabilities. Finally, I examined the reliability of the data from the knowledge measures by calculating Cronbach's alpha for the history and mathematics at pre-reading and post-reading. Cronbach's alpha is a reliability coefficient that can be calculated for dichotomous and non-dichotomous items (Crocker & Algina, 1986). The reliability coefficients for data from the pre-reading and post-reading history and mathematics tests are displayed in Table 6.

Although the pre-reading reliabilities were rather low, this was expected. That is, at pre-reading students were expected to have little knowledge. Correct responses are attributable to guessing and limited knowledge, and, thus, are rather scattered and inconsistent. In contrast, at post-reading, students have more knowledge and provide responses that are relatively consistent. Consequently, I viewed the reliability of the data from history and mathematics knowledge tests to have an acceptable level of reliability.

Conclusions

The item analyses conducted with the pilot data suggested that both the history and mathematics knowledge tested contained viable sets of items. For instance, the item difficulty and discrimination parameters were in the typical and recommended ranges. There were also notable changes in students' performance from pre-reading to post-reading and the history and mathematics measures had an acceptable level of variance. Consequently, I decided to retain all of the items on the history and mathematics knowledge tests. Further, because no changes were made to the measures or procedures, I included the data from the pilot study in the sample for the full investigation.

Method

Participants

Rationale for Sampled Population

For this investigation, the research questions were addressed using data from a sample of college students. This decision to sample college students was deliberate and based on a specific course of reasoning. First, college is time in students' lives in which the proposed model seems particularly relevant. That is, college students are actively involved in learning and achieving academically as well as making choices that will influence their educational and career trajectories. The proposed model addresses these aspects of the college experience. In contrast, middle school and high school students often have relatively little choice with regard to course enrollment and designing a specific course of academic study.

Second, the epistemological beliefs literature has focused primarily on college populations. Consequently, we know that college students think about knowledge and possess epistemological beliefs that can be assessed by others and that these beliefs are related to a variety of learning outcomes. Additionally, the structure of college students' epistemological beliefs is relatively well-established compared to the beliefs of younger populations. That is, researchers have just begun to examine the beliefs of younger students (e.g., middle-school). Initial works with younger populations suggest that the structure and specificity of beliefs in those populations differs from that of older students. However, additional research is needed with regard to the nature of the epistemological belief constructs in younger populations before these beliefs can be examined in relation to other constructs.

Third, although the expectancy-value model proposed by Eccles and Wigfield has been explored extensively with elementary, middle-school, and high-school populations, their model has not been examined with respect to college students. Additionally, previous investigations did not include the cost component of achievement value. However, cost (i.e., what a student must give up in order to achieve) seems particularly relevant at the college level. That is, a student may seriously consider whether adopting engineering as a major will "cost" her too much in terms of time spent with friends, on hobbies, or other academic pursuits. Thus, focusing on college students in the current investigation provides an opportunity to extend the current expectancy-value literature by examining the nature of students' expectancies for success and achievement values in an older population and by exploring the cost aspect of achievement value.

Description of Participants

The sample for this investigation consisted of 482 students enrolled in undergraduate courses. Student volunteers were solicited primarily from educational psychology and human development courses at a large urban land-grant university in the mid-Atlantic United States (n = 405). Additional student volunteers (n = 77) were also solicited from other sources (e.g., a small liberal arts college in the mid-Atlantic region and a non-profit undergraduate internship program located in Washington, DC). Descriptive statistics for the two subsamples (i.e., Land-Grant University and Other) are presented in Tables 7 and 8. To determine the comparability of students with respect to their gender, ethnicity, and year in school, I conducted chi-square tests. The chi-square tests were significant for gender, ethnicity, and year in school. These findings indicated that the samples were not similar with respect to their gender and ethnicity composition or students' year in school. For instance, the sample of students from the large-land grant institution had fewer males, was less diverse, and contained more freshman and sophomore students than the sample of students from other sources (Table 7).

Additionally, I conducted t-tests to determine that there were statistically significant differences in students' age and reported grade point average (GPA). As seen in Table 8, students from the land-grant university were somewhat younger and had a lower reported GPA than the sample of students from other sources. However, I did not believe that differences with respect to these sample characteristics were relevant to the

Table 7

Demographic Information by Source of Participants

Variable Level	Land-Grand University (n=405)		Other (n=77)	
	# of Students	% of Students	# of Students	% of Students
Gender*				
Male	89	22.0	27	35.1
Female	316	78.0	50	64.9
Ethnicity*				
African-American	45	11.1	17	22.1
American-Indian	3	.7	3	3.9
Asian	44	10.9	6	7.8
Caucasian	271	66.9	42	54.5
Hispanic	15	3.7	5	6.5
Pacific Islander	1	.2	0	0
Other/Multiracial	23	5.7	4	5.2
Year in School*				
First Year	59	14.6	2	2.6
Sophomore	86	21.2	8	10.4
Junior	124	30.6	21	27.3
Senior	121	29.8	44	57.1
Masters	15	3.7	1	1.3

Note. * indicates a significance difference between source groups.

Table 8

Age, Reported GPA, Course Enrollments, and Knowledge Test Performance by Source of Participants

Variable	Source: Land-Grand University *M*(*SD*)	Source: Other *M*(*SD*)
Age*	21.60 (4.62)	22.99 (5.31)
Reported GPA*	3.18 (0.55)	3.21 (0.38)
High School Courses		
History	3.58 (1.11)	3.64 (1.42)
Mathematics	4.04 (1.03)	3.88 (1.05)
Statistics	0.36 (0.59)	0.26 (0.53)
College Courses		
History*	1.96 (2.44)	2.81 (2.74)
Mathematics	2.38 (1.62)	2.00 (1.66)
Statistics	0.75 (0.75)	0.77 (0.78)
History Test Performance		
Pre-Reading Score	6.91 (2.44)	6.79 (2.85)
Post-Reading Score	9.90 (3.01)	9.70 (3.49)
Change Score	2.99 (2.56)	2.91 (2.47)
Mathematics Test Performance		
Pre-Reading Score	6.30 (2.30)	6.14 (2.54)
Post-Reading Score	8.30 (2.78)	7.62 (3.58)
Change Score	2.00 (2.40)	1.48 (2.31)

Note. * indicates a significance difference between source groups.

current study. I was more concerned about differences in students' prior knowledge and their performance on the knowledge tests. Consequently, I conducted a series of t-tests with source (i.e., Land-Grant University or Other) as the independent variable. The dependent variables were the number of high school and college history, mathematics, and college classes, students' scores on the pre-reading and post-reading history and mathematics knowledge tests, and the change in students' knowledge scores.

As seen in Table 8, students were relatively similar with respect to these variables. The only statistically significant difference between the two subsamples pertained to the number of college-level history classes students had completed. Students from the land-grant university had fewer college history courses than students from other sources. However, the content of the history text is not typically discussed in a college course (i.e., Sir Francis Galton and the history of regression). Thus, I did not view this difference as cause for concern.

Additionally, I investigated whether there were significant differences in the number of history and mathematics classes students completed in high school and college. I wanted to determine if students had significantly different levels of exposure to history and mathematics. These analyses were conducted separately for the two sources (i.e., Land-Grant University or Other). Paired-t tests with number of history classes and number of mathematics classes as the compared variables revealed that students from the Land-Grant University had taken more mathematics courses than history courses in both high school ($t = 7.50$, $p < .01$) and college ($t = 2.98$, $p < .01$). Students from other sources did not differ in their history and mathematics experiences in high school ($t = 1.27$, $p >$

.05), but they had taken more history college classes than mathematics college classes (*t* = 2.06, $p < .05$). That is, students from the Land-Grant University had taken more high school and college mathematics class than high school and college history classes whereas students from the other sources had taken more college history classes than college mathematics classes. However, given similar patterns of performance on the knowledge measures, I did not view these minor differences as cause for concern. I subsequently collapsed the two subsamples into one sample of 482 students.

Materials

In this investigation, I assessed students' beliefs about history and mathematics knowledge, their ability beliefs, expectancies for success, and their achievement values relative to the two domains. Additionally, students read passages related to history and mathematics, indicated the strategies they used while reading, and completed tests of what they learned. Students were also assessed with respect to their intentions to participate in history and mathematics related activities. Further, I obtained information about the characteristics of the students and their previous educational experiences.

A detailed description of each measure follows. Specifically, I describe the format of each measure and how it was created or modified from its previous use. Additionally, I present information about the validity of each measure. I also present reliability information for those measures not addressed in Research Questions 1-3.

Demographic Information

Students indicated their age, gender, ethnicity, citizenship, year in school, major, and cumulative reported grade point average. Additionally, students indicated the number of history, mathematics, and statistics classes taken in both high school and college.

Further, students indicated the course number for the college statistics courses and specified the course numbers.

Predictor Variables

Domain-specific epistemological beliefs. To assess students' beliefs about knowledge relative to history and mathematics, items from two domain-specific belief measures, the *Domain-Specific Beliefs Questionnaire* (DSBQ; Buehl et al., 2002) and the *Discipline-Focused Epistemological Belief Questionnaire* (DFEBQ; Hofer, 2000), were used. I chose to use both of these measures for several reasons. First, the DSBQ and the DFEBQ were developed to assess college students' beliefs about academic knowledge in specific areas of study. The DSQB (Buehl et al., 2002) was developed to address students' beliefs about history and mathematics, whereas the DFEBQ (Hofer, 2000) assesses students' beliefs about knowledge in psychology and science.

Second, neither measure assessed all of the dimensions of epistemological beliefs that I wanted to address in this investigation. That is, the DSBQ addressed students' beliefs about the integration of knowledge in history and mathematics and their beliefs about the need for effort to acquire knowledge in the respective domains (Buehl et al., 2000). Confirmatory factor analyses provided support for this four-factor structure. In contrast, an exploratory factor analysis with items from the DFEBQ revealed four factors per domain (i.e., psychology and science) related to the certainty and simplicity of knowledge, personal justification for knowing, authority as a source of knowledge, and the attainability of truth (Hofer, 2000). These factors differed from what Hofer anticipated and additional studies are being conducted to further develop and refine the measures (personal communication, 2002). For this investigation, I wanted to examine students' domain-specific beliefs about the structure of knowledge, stability of knowledge, and source of knowledge relative to their motivations, performance, and intentions.

Third, the reliability and validity of the measures were established in previous investigations (Buehl et al., 2002; Hofer, 2000). Specifically, in two previous studies with college students, the reliabilities for the integration of history and mathematics knowledge factors on the DSBQ to be used in this investigation ranged from .65 to .75. A study with the DFEBQ found that the certainty/simplicity of knowledge and authority as the source of knowledge factors identified by Hofer for psychology and science had reliabilities ranging from .51 to .81. Although the reliability for psychology was somewhat low, this may be attributable to the sampled population. That is, the students in Hofer's investigation were primarily first-year college students. Their exposure to psychology as a field of academic study was considerably more limited than their experience with science, history, or mathematics. With respect to the validity of these measures, concurrent validity was previously established by examining students responses on these measures to their responses on a domain-general measure of epistemological beliefs, the *Schommer Epistemological Questionnaire* (SEQ). At the time, the SEQ was the predominate measure of students' epistemological beliefs. The factors from the DSBQ and the DFEBQ were significantly related to factors from the SEQ, supporting the validity of the DSBQ and DFEBQ.

Consequently, I decided to administer both measures to the students and examine the items related to the pertinent belief factors. From the DSBQ, I was interested in the items loading the Integration of Knowledge factors, as they represented students' beliefs about the structure of knowledge in history and mathematics (Table 9). In previous investigations, the reliabilities for these factors with regard to history and mathematics were acceptable (e.g., history: α=.73; mathematics: α=.68, Buehl et al., 2002).

The DFEBQ addresses students' beliefs about the stability of knowledge and source of knowledge with respect to psychology and science through the Certainty/Simplicity of Knowledge and Source of Knowledge: Authority factors. However, because the Certainty/Simplicity of Knowledge factor also contains items related to the structure of knowledge (e.g., "In this subject, most work has only one right answer."), I only used those items that pertain to the certainty of knowledge. I also used those items that loaded on the Source of Knowledge: Authority factor in Hofer's (2000) previous study.

For the current investigation, I modified Hofer's items from the DFEBQ to relate to history and mathematics instead of psychology and science (Table 9). Due to the way the DFEBQ was constructed this modification involved substituting the words "history" and "mathematics" for "psychology" and "science." Additionally, when Hofer conducted her study, students completed separate questionnaires for her two target domains (i.e., psychology and science). In contrast, the measure used in the current investigation had items related to the two target domains (i.e., history and mathematics) randomly interspersed. Buehl et al. (2002) used this procedure in their work with the DSBQ.

Students responded to each item using a 10-point Likert scale ranging from *strongly disagree* (0) to *strongly agree* (9) as follows:

0	1	2	3	4	5	6	7	8	9
Strongly Disagree								**Strongly Agree**	

Table 9
Sample Epistemological Belief Items

Epistemological Belief Assessed (Measure) Item	Item Number for Mathematics
Isolation of History (DSBQ)	
27. History is related to day to day life. *	6
29. It is important for students to integrate new ideas in history with what they already know. *	36
33. There are links between history and other disciplines.*	22
34. Information learned in history is useful outside of school. *	18
Certainty of History Knowledge (DFEBQ)	
12. Answers to questions in history change as experts gather more information. *	39
15. Principles in history are unchanging.	38
17. Most of what is true in history is already known.	35
19. Truth is unchanging in history.	20
Authority as the Source of History Knowledge (DFEBQ)	
13. I am most confident that I know something in history when I know what the experts think.	24
16. If you read something in a textbook for history, you can be sure it's true.	28
37. Sometimes you just have to accept answers from the experts in history, even if you don't understand them.	23
40. If my personal experience conflicts with ideas in the history textbook, the book is probably right.	4

Note. * indicates a reverse coded item.

Responses were coded such that a higher score represents agreement with a less sophisticated epistemological stance (i.e., knowledge exists in isolation, knowledge is certain, authority is the source of knowledge) and a lower score represents agreement with a more sophisticated viewpoint (i.e., knowledge is complex and well-integrated, knowledge is uncertain, knowledge is derived from personal experience and reason). Hofer (2000) used this coding scheme in her original work with the DFEBQ. Consequently, adopting this scheme required the fewest number of items to be reverse coded. The complete formatted measure is presented in Appendix C.

Ability beliefs and expectancies for success. To assess students' ability beliefs and expectancies for success relative to history and mathematics, I adapted items used by Eccles, Wigfield, and their colleagues (Eccles & Wigfield, 1995; Jacobs et al., 2002; Wigfield et al., 1997). These items were originally developed for elementary, middle-school, and high-school students who were currently enrolled in specific courses (e.g., mathematics) and were administered using a seven-point scale. Some of the items developed by Eccles and Wigfield are written in the form of questions and others that are open-ended statements. Additionally, some of their items include social comparisons or comparisons across various activities. The items developed for this investigation also possessed these features. The modifications made to the items pertained to making the items more appropriate for college-age students who may not necessarily be enrolled in a specific course at the time of the investigation.

With respect to item modifications, items were worded to refer specifically to college level courses and tasks. For example, the original Eccles and Wigfield item written "How well do you think you will do on your math course this year?" was re-written as "How well do you think you would do in a college mathematics course?" For items that drew on social comparisons, students were directed to use the other students in their academic major as a social comparison group. Thus, an item such as "If you ordered all the students in your math class from the worst to the best in math, where would you put yourself?" was modified to be "In comparison to other undergraduates in your major, how good are you at college mathematics?." Additionally, I developed new items that were appropriate for a college sample (e.g., "How successful would you be in a mathematics-related career?") and that were specific to the task students would be asked to do as part of the current study (e.g., "You will be asked to read a passage related to mathematics and respond to some questions based on what you read. How well do you expect to do on the test?"). These items do not directly map onto items previously used by Eccles and Wigfield. However, they still reflect students' beliefs about their present abilities and future performances.

The modified and new items were shown to two experts in the field of education, one of whom is intimately familiar with the Eccles and Wigfield expectancy-value constructs. Minor modifications were made to the items based on the comments of these experts. After making modifications to the Eccles and Wigfield items and creating new items appropriate for college students, for each domain (i.e., history and mathematics), there were three items that addressed students' beliefs about their current abilities (i.e., ability beliefs) and seven items that addressed students' beliefs about their expected performance on future tasks (i.e., expectancies for success). An expert in statistics and measurement suggested that four items per construct would be ideal for modeling purposes. Thus, I developed an additional item pertaining to students' ability beliefs (i.e., "How would you describe your ability in history/mathematics?").

From the pool of expectancy items, I selected four items that reflected the construct in the in both domains. Specifically, for each domain, I dropped three items (i.e., "How well do you think you would do in a college history/mathematics course?," “How well would you expect to do in a history/mathematics test?,” and "You will be asked to read a passage related to history/mathematics and respond to some questions based on what you will read. Compared to other undergraduates in your major, how will do you expect to do on the test?"). These items were eliminated because they were similar to other items (e.g., "Compared to other undergraduate in your major, how well do you expect to do on a college history/mathematics test?" and "You will be asked to read a passage related to history/mathematics and respond to some questions based on what you will read. How will do you expect to do on the test?").

The items were administered to a college student. After completing the items, the student commented on items that seemed awkward or strangely worded. The items were modified based on these comments. A list of the items included in the final measure with their anchor points is provided in Table 10 Based on the steps I took develop these items, I felt that they represented a valid measure of students' ability and expectancy beliefs in history and mathematics. That is, the items were based upon a valid measure used in previous investigations, examined by individuals who were experts with regard to the constructs and/or methodology, and examined by a individual from the population to be

Table 10

Sample History and Mathematics Ability and Expectancy Belief Items

Construct Sample Item (Item Anchors)	Item Number for Alternate Domain
History Ability Beliefs	
2. In comparison to your other academic studies, how good are you in history? (Much worse/Much Better)	11
28. How good are you at history? (Not at all good/Very good)	46
History Expectancy for Success Beliefs	
6. Compared to other undergraduates in your major, how well would you expect to do on a college history test? (Much worse than other students/Much better than other students)	24
10. You will be asked to read a passage related to history and respond to some questions based on what you will read. How well do you expect to do on the test? (Not at all well/Very well)	44
Mathematics Ability Beliefs	
9. In comparison to other undergraduates in your major, how good are you at mathematics? (Much worse than other students/Much better than other students)	28
14. How would you describe your mathematics ability? (Not at all good/Very good)	41
Mathematics Expectancy for Success	
5. How successful would you be in a mathematics-related career? (Not very successful/Very successful)	20
17. How good would you be at learning something new in mathematics? (Not at all good/Very good)	26

sampled. Students responded to the items on the 10-point Likert scale format used for the belief items. Items were scored so that higher scores indicated that students had higher levels of confidence in their respective history and mathematics abilities and expectancies for success.

Achievement values. The interest, importance, and utility value items I employed in this investigation were also adapted versions of those used by Eccles, Wigfield and colleagues. Similar to the ability and expectancy items, I used the items in their original form or modified them to be appropriate for the current sample of college age students (Tables 11 and 12; Eccles & Wigfield, 1995; Jacobs et al., 2002; Wigfield et al., 1997). For example, "In general, I find working on math assignments…very boring/very interesting?" was re-written as "I find working on history/mathematics tasks or problems…very boring/very interesting."

Additionally, I developed items to assess the cost value aspect of achievement values. These items are based on Eccles and Wigfield's (e.g., Eccles et al., 1983; Wigfield & Eccles, 2000) discussion of cost value, as well as items Battle and Wigfield (2003) developed to assess students' perceptions of the cost associated with attending graduate school. The items I developed pertain to history and mathematics (Tables 11 and 12). For instance, in their work with college students' perceptions of graduate school, Battle and Wigfield (2003) had cost items that addressed whether the time, effort, and money spent on graduate school would be "worth it" (e.g., "When I think about all the work required to get through graduate school, I'm not sure that getting a degree is going to be worth it in the end" and "I worry that spending all the time in graduate school will take time away from other activities I want to pursue while I'm still young"). I developed similar items

Table 11

Sample History Achievement Value Items

Construct Sample Item (Item Anchors)	Item Number for Mathematics
History Intrinsic Value	
4. How much do you like history? (Not very much/Very much)	19
23. I find working on history tasks or questions… (Very boring/Very interesting)	38
History Important Value	
15. How important is it to you to do well in a college history course? (Not at all important/Very important)	39
31. Compared to your other academic studies, how important is it for you to be good at history? (Not as important/Very important)	24
History Utility Value	
27. How useful is the history content you learned in school for performance in your other courses? (Not at all useful/Very useful)	29
37. Compared to your other academic studies, how useful is what you learned in history? (Not as useful/A lot more useful)	21
History Cost Value	
3. How worthwhile is the effort required to learn something in history? (Not at all worth it/Very worthwhile)	16
7. The time I would spend learning new history content is…(A waste of time/Very worthwhile)	22

Table 12

Sample Mathematics Achievement Value Items

Construct Sample Item (Item Anchors)	Item Number for History
Mathematics Intrinsic Value	
13. I find working on number puzzles and games… (Very boring/Very interesting)	47
25. Compared to my other academic studies, mathematics is… (Very boring/Very interesting)	30
Mathematics Important Value	
1. How important is it to you to understand mathematical content? (Not at all important/Very important)	35
12. To me, being good at solving problems that involve mathematics or mathematical reasoning is… (Not at all important/Very important)	43
Mathematics Utility Value	
8. In general, how useful is what you learned in mathematics? (Not at all useful/Very useful)	42
45. How useful is the mathematical content you learned in school for your future career? (Not at all useful/Very useful)	32
Mathematics Cost Value	
33. Compared to my other academic studies, the time spent learning mathematics is…(A waste of time/Very worthwhile)	40
48. How worthwhile is the time spent reading an article or a book about mathematics? (A waste of time/Very worthwhile)	36

related to history and mathematics (e.g., “How worthwhile is the effort required to learn something new in history/mathematics?” and “Compared to my other academic studies, the time spent learning mathematics is ….a waste of time/very worthwhile”).

The achievement value items were subjected to the same validation procedures used with the ability and expectancy items. Specifically, they were shown to the content experts who commented on the ability and expectancy items. After modifications, for each domain, there were three items related to intrinsic value, five items related to importance value, five items related to utility value, and four items related to cost. In an effort to have four items per construct, I developed an additional item related to intrinsic value (i.e., "Compared to my other academic studies, history/mathematics is…very boring/very interesting"), dropped one of the importance items (i.e., “How upset would you be if your got a low mark in mathematics?”) and one utility value items (i.e., "Presently, how useful is the mathematical content you learn in school for everyday life"). After making these changes, there were four items per construct per domain. Additionally, for each construct, there was at least one comparison item (e.g., Compared to your other academic studies, how important is it to you to be good at history/mathematics?").

The 16 achievement value items were also administered to the college student who commented on odd or awkwardly phrased items. Items were modified based on these comments to make them easier for college students to comprehend and respond to the items. Similar to the ability and expectancy items, I felt that these items (Tables 11 and 12) were a valid assessment of students' achievement values. The items were based on previous measures, examined by experts, and administered to a member of the sampled population. Additionally, items were modified based on expert and student comments.

Students responded to the items using a 10-point Likert scale and the anchor points varied depending on the item. The items were scored such that higher scores represented higher level of intrinsic, importance, and utility value, and lower levels of cost value. That is, the cost value items were worded such that higher scores indicated that students' perceived the time and effort needed to achieve in history or mathematics as worthwhile. The complete formatted measure for the ability, expectancy, and achievement value items is presented in Appendix D.

Texts

To situate the epistemological belief and motivation constructs in a learning and achievement context, I wanted the students to encounter a learning task. After much consideration, I decided to present students with an informative text from which they could learn new information. In order to assess the proposed model in both history and mathematics, I needed a text that contained content from both domains. Based on the advice of a group of experts in cognition, motivation, text-processing, methodology, and statistics, I developed a text related to the topic of statistical regression.

Rationale for selected topic. The decision to focus on the topic of statistical regression was very deliberate. First, I wanted a text that contained both historical and mathematical information. Initially, I considered using pre-existing texts on disparate topics (i.e., the role of American Indians in the Civil War and the correlation coefficient). However, this presented a confound with respect to topic. That is, the learning task related to two different topics in the two domains (i.e., history and mathematics). In contrast, the topic of statistical regression could be addressed from both a historical and a mathematical perspective.

Second, I wanted the students to be relatively unfamiliar with the presented information so as to maximize the opportunity for learning. Although this was relatively easy with respect to history, determining an appropriate topic and text for mathematics was somewhat more difficult. Specifically, I wanted the text to contain mathematical content that would be unfamiliar to the students. However, because the sampled students will come with a variety of previous mathematics experiences, I could only assume a rudimentary level of prior knowledge (e.g., high-school algebra, geometry). This limited the topics that could be addressed, as well as the use of various mathematical symbols. Subsequently, after consultation with my group of experts, I decided to focus on how statistical regression is used to make predictions. This subject matter seemed appropriate for several reasons. First, the college students I planned to sample would not have extensive exposure to this content. At most, regression may have been presented in a course addressing a variety of other statistical techniques (e.g., correlation and t-tests). Second, regression can be discussed without prior knowledge of other statistical concepts in a way that most individuals can understand. Third, regression could be discussed from a historical perspective as well as a mathematical perspective.

I could not locate texts related to the history and mathematics of regression that satisfied the criteria discussed above. Consequently, I developed two-part text based on a variety of other texts, consultation with a content expert, consultation with text experts, and my own content knowledge. The first section of the text discusses Sir Francis Galton and the history of regression. The second section of the text describes how social scientists use regression is used to make predictions. The sections were written so that they could be used independent of one another. However, transition paragraphs were such that the history section should precede the mathematical section when they are used together. Descriptions of the two-part text are presented below.

A historical perspective on regression. For the history section of the text, I relied heavily on the content and structure presented in *Statistics in psychology: An historical perspective* (Cowles, 1989). My original intention was to modify excerpts from this book related to Francis Galton and the history of regression for students to read. However, the book is rather densely written for college undergraduates unfamiliar with the content. Consequently, I rewrote substantial portions of the excerpts from the book and, using additional information from other sources (e.g., Jones, 1998), crafted a text suitable for college students.

The structure and content from Cowles (1989) served as starting point. Paragraphs were rearranged, sentences rewritten, and information was added and deleted in an effort to create a passage that was coherent, comprehensible, and appropriate in terms of length and content. I revised this section of the text multiple times. Additionally, four experts examined this section of the text (i.e., two experts in text and text processing, a content expert, and a graduate student experienced in teaching undergraduates). Multiple changes were made based on comments from these experts. These changes included word changes, deleting irrelevant information, correcting misinformation, as well as using the footnoting system often found in history texts.

This process of revisions resulted in a 1254 word section about the Galton and the history of statistical regression. More specifically, this section of the text addressed the origins of the term "regression," factors contributing to Galton's conceptualization of regression, and the studies related to the development of regression. This section of the text also referred to the current use of regression to make predictions. This section, entitled "Galton and the Origins of Regression," consisted of 12 paragraphs and one table displaying Galton's original parent/child height data. With respect to readability statistics, it had a Flesch-Kincaid Grade Level of 12.0 and Flesch Reading Ease score of 32.3.

A mathematical perspective on regression. For mathematics, I wanted to present students with a section of text that addressed the mathematics of regression in a way that could be easily understood by an individual unfamiliar with statistics. However, I could not find a naturally-occurring text that fit this criterion. Most textbook discussions of regression assumed students are already familiar with the concept of correlation. Consequently, I also wrote the mathematics section of the text. Specifically, this section addressed how regression is used by social scientists to make predictions and was created so that the information needed to understand the concept of regression was presented in the passage.

Before attempting to write this section of the text, I first met with an expert in statistics and measurement. Together, we created an outline of the topics that should be included as well as the order in which they should be presented. Using this outline, I drafted an initial version, drawing from multiple sources. For instance, I relied heavily my content knowledge of regression and my pedagogical knowledge related to teaching statistics. Additionally, I looked to course notes, textbooks, and online sources for assistance with phrasing and presentation of material. To support students' understanding of the material, I also developed four figures that illustrate information present in text.

Multiple drafts of the mathematics section of the text were read by my statistics and measurement expert. This section of text was also shown to the two experts in text and text processing and the graduate student experienced in teaching undergraduates. Based on their comments, I revised the section repeatedly in an effort to create an accurate and understandable discussion of how regression is used to make predictions in the social sciences.

The final version of the mathematics section of the text introduces necessary terminology (e.g., predictor variable, scatterplot), describes different types of linear relations (e.g., strong positive relations), discusses the conditional distribution, conditional mean, and regression line, presents the regression equation, and defines the error of estimate and describes its effects on the accuracy of predictions. The information in this section, entitled "Using regression to make predictions," is referenced using the in-text citation format often used in the social sciences. The mathematics section of the text contains 1561 words, 10 paragraphs, and four figures, is written at a 12.0 Flesch-Kincaid Grade Level, and has a Flesch Reading Ease score of 40.7. The complete two-part text is provided in Appendix E.

Outcomes

Reported strategy use inventory. Immediately after reading each section of the text, students indicated the strategies they relied on while reading using a 21-item strategy inventory. That is, the same strategy measure was administered twice (i.e., once after the history section of the text and once after the mathematics section of the text).

Some of the listed strategies were more surface-level text processing strategies (e.g., reread part of the passage and rephrased main ideas in my own words), whereas others reflected deeper processing (e.g., questioned the information and related the information to what I already knew). Space was also provided for students to write in additional strategies that may not have been included in the list.

In prior investigations, this measure was found to be reliable and valid (e.g., Alexander, Murphy, Woods, Duhon, & Parker, 1997; Sperl et al., 2002). Specifically, in previous studies with college students, the reliability of this measure was acceptable (e.g., .80; Knight & Alexander, 1994). Because the measure was used in previous studies and contained many of the strategies discussed in the literature, it was believed to be a valid measure of the strategies students employed when reading various types of text.

Students were presented with the list of 21 learning strategies and asked to indicate the strategies on which they relied to comprehend and remember the text content (Appendix F). Specifically, students were asked to check (✓) all of the strategies that they used and asterisk (*) those strategies that were most useful. Strategies that were unmarked were scored as 0. Those marked with a check (i.e., used strategy) were scored as 1, and asterisked strategies (i.e., those found most useful) were scored as 2.

Principal components analyses with varimax rotations were conducted on data from the strategy inventories to form strategy composites. The same procedures were used to analyze the history and mathematics data separately. I first ran a principal components analysis with all of the strategies. However, the analysis suggested multiple components that were not theoretically meaningful. An examination of the frequency with which the strategies were used indicated that several strategies were rarely employed (e.g., created personal examples). Consequently, I eliminated strategies that were not used by at least 25% of the students from additional analyses (Table 13). I then conducted additional principal components analyses separately for the history and mathematics strategy measure.

To determine the appropriate number of components to extract, I examined the scree plot as well as the number of components with eigen values greater than 1.00. A three-component solution was suggested for the history and mathematics strategy measures. Those strategies with loadings greater than .4 were used to define the respective history and mathematics strategy components (Tables 14 and 15). Although there were minor variations in the strategy items that loaded on each component, the underlying meaning of the components appeared to be consistent across domains. For instance, the first component pertained to more low-level or surface-level strategies used to "get through" reading the text (e.g., skip boring parts of the passage and ignore words or phrases not critical to understanding). I refer to this component as Surface-Level Strategy Use. The second component pertained to strategies used to interact with and create a model of information presented in the text (e.g., rehearse the main idea, reflect on the reading, and create mental images). This component is referred to as Moderate-Level Strategy Use. The third component represented the use of higher-level strategies related to internalizing information from the texts and relating it to prior knowledge (e.g., related the information to what I already knew and critiqued the information based on my prior knowledge). This component is referred to as Deep-Processing Strategy Use.

Table 13

Frequency of Use for Items on the Strategy Inventory

Strategy	Strategy Usage (%) History	Strategy Usage (%) Mathematics
1. reread parts of the passage	75.9	72.2
2. skipped difficult parts of the passage	**16.2**	31.5
3. skipped boring parts of the passage	**23.7**	47.1
4. changed my reading rate	63.3	63.3
5. questioned information in the text	**20.3**	**17.8**
6. created mental images of what I read	56.8	44.0
7. rehearsed the main idea	35.1	32.8
8. critiqued the information based on my prior knowledge	41.3	40.0
9. reflected on the reading	47.9	34.4
10. looked for salient details	34.9	36.5
11. created personal examples	**15.4**	**18.0**
12. mentally summarized the text	56.4	51.2
13. related to information to what I already knew	59.3	60.2
14. rephrased main ideas in my own words	40.2	32.5
15. elaborated on the main idea	**19.3**	**17.4**

(continued)

Table 13 (continued)

Strategy	Strategy Usage (%)	
	History	Mathematics
16. ignored words or phrases not critical to understanding	45.4	45.4
17. used context to determine meaning	41.5	36.1
18. took notes	**6.8**	**8.1**
19. assessed the credibility of the cited authors	**8.3**	**5.4**
20. underlined important information	**20.7**	**24.9**
21. other	**10.2**	**11.8**

Note. Bolded percentages indicate items that were dropped from future analyses because they were used by less than 25% of the sample.

The component loadings and reliabilities for the respective history and mathematics strategy measures are displayed in Tables 14 and 15. The reliabilities for several of the components were rather low. I felt that this was attributable to several factors. First, a small number of strategy items loaded on each component. Thus, these reliabilities may have been low due to the number of items. Second, the scale on the strategy inventory was limited (i.e., 0, 1, or 2). The limited scale decreased the variability in students' responses which may have had an averse affect on reliability. Third, the strategy inventory was a self-report measure that students completed after reading the texts.

Table 14

History Strategy Component Loadings and Reliabilities

Strategy Item	Component 1	Component 2	Component 3
10. looked for salient details	**.632**	.003	-.045
17. used context to determine meaning	**.564**	.292	.252
4. changed my reading rate	**.530**	.006	-.027
16. ignored words or phrases not critical to understanding	**.479**	-.247	.277
14. rephrased main ideas in my own words	.033	**.639**	.022
7. rehearsed the main idea	-.076	**.584**	.075
9. reflected on the reading	-.103	**.575**	.141
12. mentally summarized the text	.299	**.542**	.094
8. critiqued the information based on my prior knowledge	.074	.048	**.781**
13. related to information to what I already knew	.084	.134	**.730**
6. created mental images of what I read	-.074	.402	**.442**
1. reread parts of the passage	.334	.363	-.266
Reliability (α)	.35	.52	.52

Note. Bolded loadings indicate component assignment.

Table 15

Mathematics Strategy Component Loadings and Reliabilities

Strategy Item	Component 1	2	3
2. skipped difficult parts of the passage	**.762**	.030	-.210
3. skipped boring parts of the passage	**.746**	-.168	-.150
16. ignored words or phrases not critical to understanding	**.648**	.098	.213
14. rephrased main ideas in my own words	.037	**.620**	.157
9. reflected on the reading	-.065	**.602**	.159
12. mentally summarized the text	-.067	**.601**	.128
7. rehearsed the main idea	.033	**.551**	.087
1. reread parts of the passage	-.240	**.498**	-131
17. used context to determine meaning	.194	**.440**	.206
4. changed my reading rate	.059	**.410**	-.110
6. created mental images of what I read	-.087	**.406**	*.379*
8. critiqued the information based on my prior knowledge	-.002	.052	**.795**
13. related to information to what I already knew	-.042	.068	**.748**
10. looked for salient details	.269	.153	.247
Reliability (α)	.59	.63	.56

Note. Bolded loadings indicate component assignment.

Pre-reading and post-reading knowledge measures. Students' knowledge relative to the two-part text (i.e., the history of regression and the mathematics of regression) was assessed with two multiple-choice tests of students' knowledge. To obtain an understanding of how much students learned from each section of text, the knowledge measures were administered before and after students read the text. Subsequently, I examined the difference in students' scores on the knowledge tests from pre-reading to post-reading. This provided an estimate of what students learned from the text.

The knowledge tests were developed and refined through a series of steps. First, I examined the history and mathematics sections of the texts and created a list of the major topics addressed in each. Second, I created multiple-choice items related to these topics. Each item had a stem, a correct response option, and three distractor options. Items were also created by experts in teaching, assessment, and statistics

The items were designed to address different levels of students' understanding. That is, although I was using multiple-choice items, I wanted to assess students' higher levels of conceptual understanding. Bloom's Taxonomy is one classification system that can be used to identify items addressing different levels of understanding. However, given the length of the texts, students' exposure to the information, and the intended length of the tests, it was not possible to develop items that addressed all six levels of understanding in Bloom's Taxonomy. Consequently, I decided to collapse the levels of understanding in Bloom's Taxonomy into low-level questions and high-level questions. Bracht and Hopkins (1970) describe students' higher cognitive abilities as the "ability to apply, conceive, design, and integrate concepts and segments of subject matter (p. 360)."

Consequently, questions were considered low-level if they pertained to Bloom's categories of Remembering and Understanding and high-level if they pertained to Bloom's categories of Applying, Analyzing, Evaluating, and Creating.

Items were revised as they were created in an effort to improve their quality, clarity, and accuracy. The items were also reviewed by my expert in statistics and measurement and changes were made based on his suggestions. This process resulted in an initial pool of 32 items related to the history section of the text and 22 items related to the mathematics section.

Third, after generating the initial item pool, I classified each item as a low-level or high-level question using the detailed descriptions of Bloom's categories provided by Anderson and Krathwohl (2001) in *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives.* Another individual also classified the items using Anderson and Krathwohl's (2001) descriptions as a guide. I examined our agreement with respect to whether each item was a low- or high-level question. For items for which there was disagreement, we discussed the reasons behind our classifications and referred to the Anderson and Krathwohl descriptions. Most disagreements were settled in this manner. For those that were not, the items were marked as problematic.

Fourth, I created two tables containing the concepts and topics discussed in each section of the text. I then charted which item addressed the various concepts and topic, indicating if the item was a low- or high-level question. This step was taken to ensure that the items adequately covered the information provided in the text. Fifth, I selected items for each section of text (i.e., history and mathematics) that I felt best represented the material. Additionally, in effort to create tests of similar difficulty for both history and mathematics, I tried to select a similar number of low- and high-level questions across texts for both the history and mathematics knowledge tests. Thus, item selection was based on content coverage and type of item as well as the quality of the item.

Sixth, I showed the selected items to my statistics and measurement expert. We examined each item individually with respect to the stem, correct response, and distractor options. We also examined the items in relation to one another to ensure that there was not too much overlap with respect to content and that answers were not provided in other items. Modifications were made to improve item quality, clarity, and accuracy. From this pool of items, we selected those that we thought were best in terms of content coverage, item quality, and level of understanding assessed. Specifically, the final knowledge tests for both history and mathematics consisted of 10 low-level questions and five high-level questions. As previously described, these items were piloted with a group of 24 college undergraduates. No additional modifications were made to the items.

The items included on the final knowledge tests are in Appendix G. Students' responses were scored using a dichotomous scale (i.e., 0 to indicate an incorrect responses and 1 to indicate a correct response). The reliabilities for the history knowledge test data, calculated using Cronbach's alpha, were .49 at pre-reading and .71 at post-reading. For the mathematics knowledge test data the reliabilities were .44 at pre-reading and .64 at post-reading.

Future intentions. Students' future intentions with respect to history and mathematics were assessed using four items per domain. The items addressed students' desire to pursue history and mathematics related activities in the future. These items were developed and revised through a series of steps. Specifically, the items were edited for grammar and clarity. An undergraduate student also completed and commented on an initial version of the items. These comments were also used to revise the items. For example, the student thought that the items "I would like to do a leisure activity that is related to history (i.e., read a historical book, be a member of a discussion group, re-enact historical events)" and "I would like to do a leisure activity that is related to mathematics (i.e., work on a number puzzle or logic problem)" were awkward and somewhat strange. These items were revised to refer to a specific leisure activity (i.e., read a history or mathematics book).

These changes resulted in a list of eight activities. Students rated each of the activities using a 10-point Likert scale, ranging from note very likely (0) to very likely (9). Higher scores indicated a stronger intention to engage in the various activities. The final list of activities is presented in Table 16. (See Appendix H for the formatted measure).

To assess the reliability of the data pertaining to students' future intentions, I used a measure of construct reliability for latent variables (Hancock, 2001; Hancock & Mueller, 2001). I assessed students' future intentions as a latent variable reflected by the intentions items, not a composite variable. Consequently, Cronbach's alpha, a common measure of reliability used to assess the reliability of composite scores, was not an appropriate. The measure of construct reliability presented by Hancock and Mueller (i.e., *H*; 2001) can range from 0 to 1. Thus, its interpretation is somewhat similar to Cronbach's alpha. Specifically, values closer to 1 indicate greater reliability. The

Table 16

Sample Activities for the Intentions Measure

Domain Sample Activity	Item Number for Alternate Domain
History	
1. Take a history course.	5
4. Pursue a history-related career.	7
Mathematics	
2. Choose to learn more about mathematics.	6
8. Read a book about mathematics.	3

coefficient for the history intentions factor was .92 and the mathematics intentions factor had a construct reliability coefficient of .93.

Procedure

The study materials were administered to groups of students outside of class. Students who participated in the study received course credit or had their name entered into a drawing for a cash reward. Additionally, any student who completed all of the measures also had their name entered into the cash drawing.

The materials were presented to the students in a specific order. This order was determined based on several reasons. For instance, in order to control for potential order effects it is important to counterbalance the materials whenever possible. However, there were some specific constraints on the order of the materials and counterbalancing. Specifically, I did not want students to complete the knowledge measures immediately before or after reading the texts. Additionally, it is important that students complete a task of the same length between reading and responding to the post-reading knowledge measures. Consequently, the materials were ordered in the following manner.

First, students completed the consent form and contact information sheet for the cash drawing. Second, they completed the pre-reading knowledge measures with respect to Galton and the history of regression (i.e., history) and using regression to make predictions (i.e., mathematics). The order of the knowledge measures was counterbalanced. Third, students responded to the epistemological beliefs, the motivation, and future intentions measures. The three measures were counterbalanced across participants.

Fourth, students read each section of the text and completed a strategy inventory after reading each section. Fifth, the students completed the background information sheet. Finally, students responded to the post-reading knowledge measures related to the two-part text. The order of the post-reading knowledge measures was counterbalanced across participants.

Data Analysis

Research Questions 1 - 3

To address the first three research questions, I used confirmatory factor analyses to determine if the items loaded on the predicted factors. Analyses were conducted separately for epistemological beliefs, ability beliefs and expectancies for success, and achievement values. Both history and mathematics items were included in each analysis to ensure that the constructs were indeed domain specific. Additionally, the hypothesized confirmatory factor models were tested against alternative models of the data.

For instance, a six-factor model was tested for students' domain-specific epistemological beliefs. Three factors pertained to the structure of knowledge, stability of knowledge, and source of knowledge for history, and three factors pertained to the same beliefs relative to mathematics knowledge. A four-factor model was assessed for students' ability beliefs and expectancies for success in the respective domains. However, based on previous findings, it was likely that a two-factor model (i.e., one factor per domain) would provide a satisfactory fit in relation to the four-factor model. That is, it was likely that the two-factor model would not fit the data statistically worse than the four-factor model. Consequently, one of the alternative models tested against the four-factor model was a two-factor model in which the ability and expectancy factors were collapsed within each domain. Finally, an eight-factor model was assessed with respect to students' achievement values. Items related to the four types of achievement values (i.e., interest, importance, utility, and cost) were expected to load on separate factors for each domain (i.e., history and mathematics).

For each confirmatory factor model, I assigned each item to the appropriate factor. Given the similarity in the items across domains, I also allowed the error terms of complementary items (e.g., “How much do you like history?” and “How much do you like mathematics?”) to covary. All factors were allowed to covary. After specifying the model in this manner and examining the fit of the model to the data, I made adjustments that were theoretically justifiable and statistically significant. That is, I only included paths suggested by the Lagrange Multiplier test if there was a reason why the terms should be related. For example, if two items contained similar content or wording, their error terms were allowed to covary. Additionally, I considered allowing items to cross-load if there appeared to be a theoretical reason as to why the item may load on two factors. The Wald test was also used to remove non-significant error to error covariances. The reliability of the resulting factors was assessed using coefficient *H* (e.g., Hancock, 2001).

Research Question 4

The fourth research question used to guide this investigation involved testing a portion of my proposed model (see Figure 1).

Rationale for model to be assessed. In this investigation, I chose to focus only on a portion of the proposed model (see Figure 2). This decision was made, in part, based on logistical constraints. That is, assessing all of the constructs included in Figure 1 would have put a tax on participants in terms of time and effort. Additionally, an extremely large sample size would be required to assess the model adequately. Consequently, in light of these constraints, I chose to focus on a select number of variables in the model and examine their interrelations. I provide justification for my decisions in the order that the variables are presented in the model.

First, I examined three different dimensions of students' epistemological beliefs (i.e., beliefs about the stability, structure, and source of knowledge). In the epistemological belief literature, there appears to be agreement that these dimensions reflect epistemological beliefs. In contrast, there has been some discussion as to whether beliefs about the acquisition of knowledge and the ability to acquire knowledge are more related to epistemology or intelligence.

Second, with respect of the construct of motivation I focused on expectancy-value theory. In particular, I focused on the Eccles and Wigfield expectancy value model (e.g., Wigfield & Eccles, 2000). As previously discussed in Chapters 1 and 2, I chose the Eccles and Wigfield expectancy-value model because it addresses two of the major issues in the motivation literature, there are apparent links to epistemological beliefs, and it has implications for student learning and development at the college level.

Third, in terms of cognitive processing, I focused on students' reported strategy use as they read the history and mathematics passages. Reported strategy used seemed particularly relevant given the nature of the task (i.e., reading). Additionally, previous investigations have identified links between epistemological beliefs and reported strategy use. Thus, the inclusion of reported strategy use offered the opportunity to replicate previous findings. Further, I examined reported strategy use based on the sophistication of the strategies employed. Again, this decision was based on previous findings that students use strategies of differing levels of sophistication depending on their epistemological beliefs.

Fourth, as outcome variables, I focused on students' knowledge gains after reading the text related to history and mathematics and their future intentions to engage in history and mathematics activities. These outcome variables were chosen because they represent learning outcomes related to students' knowledge and to their future motivation. To assess what students learned from reading the passages, I calculated a gain score by subtracting the pre-reading test score from the post-reading test score. The decision to use gain scores instead of using the pre-reading knowledge score as a covariate was made in an effort to test the most parsimonious model. That is, gain scores and covariates both offer a means to examine students' performance on the post-reading test while controlling for their pre-reading test performance (Maxwell & Delaney, 1989). However, covariates are typically used to compare two groups on an outcome variable (Maxwell & Delaney, 1989). Group comparison was not one of the goals of this investigation. Additionally, including a covariate in the model would have added additional paths to be estimated. Consequently, I chose to use gain scores as a measure of what students learned from the text.

Several variables were excluded from the model I tested. For example, I did not include race, gender, and other demographic variables in the model. Based on the current literature, the inclusion of such variables did not seem relevant. For instance, the epistemological belief literature suggests that there are not significant gender differences in students' beliefs due to gender. In studies where differences were identified, such differences were attributable to differences in prior knowledge and experience. Further, there was no reason to believe that differences in the degree to which students endorse different beliefs will influence the relations between these beliefs and other variables in the proposed model.

Additionally, I did not include a measure of students' learning tactics and immediate responses in the model I tested. The decision to exclude this aspect of the model was based on several practical and logistical constraints. For instance, I did not want to add yet another measure to the packet of tasks students were asked to complete. Additionally, variables such as effort and persistence can be difficult to adequately assess. Although the amount of time students spend on the task could be used as a proxy variable for their effort and persistence, an accurate assessment of time would have required administering the tasks to students individually or via computer. Given the sample size required to test the model, this was not practical.

The decision to exclude a measure of students' learning tactics and immediate responses may have affected the findings in several ways. First, the model proposes that learning tactics and immediate responses may mediate the relation between students' motivation and learning outcomes. Consequently, in the current investigation, the relation between students' competency beliefs and achievement value and their knowledge gains and future intentions may appear to be stronger than if a measure of learning tactics and immediate responses (e.g., persistence) had been included. That is, if effort, for example, does indeed mediate the relation between students' competency beliefs and performance, the direct path from motivation to performance may have appeared stronger than they would have been if effort was included in the model.

Second, the model suggests a reciprocal relation between cognitive processing and learning tactics and immediate responses. Additionally, both cognitive processing and learning tactics and immediate responses are believed to influence students' learning outcomes directly. The exclusion of a learning tactic and immediate response variable may have influenced the model with respect to the relation between reported strategy use and knowledge gains. That is, any variance that may have been shared by both cognitive processing and learning tactics was attributed solely to reported strategy use. If a learning tactic (e.g., persistence) was included, the relation between reported strategy use and knowledge gains may have been weaker.

Assessment of the model. I employed structural equation modeling to assess the proposed relations between students' domain-specific epistemological beliefs, competency beliefs, values, reported strategy use, performance, and future intentions (see Figure 2). Models were tested separately for history and mathematics. For the epistemological belief factors, competency belief factor and future intentions factor, individual items were used as indicators of the latent constructs. For the value construct, composite scores for each type of achievement value (i.e., interest, importance, utility, and cost) were used as indicators of the factor. Finally, reported strategy use and task performance were represented as measured (i.e., non-latent) variables.

The decision to examine achievement value as a single construct was based on both practical and methodological reasons. First, including separate factors for each aspect of achievement value (i.e., interest, importance, utility, and cost) would have increased the complexity of the structural model, requiring an even larger student sample. Second, previous research indicated that students' achievement values are highly correlated. The results from Research Question 3 also indicated that these aspects of achievement value were strongly related. Thus, if the four aspects of value were included as separate factors, there may have been problems with respect to multicollinearity. Further, previous investigations that examined the structural relations among achievement value and other variables have often focused on a specific aspect of value or examined values as a unitary construct (e.g., Meece et al., 1990). Consequently, given the complexity of the current structural model, the potential multicollinearity, and the precedent set by prior investigations, I felt that it was justified to include achievement value as a single construct.

Figure 2 depicts a line with double-headed arrows connecting competency beliefs and value. This line indicates that I expected these variables to covary. However, because they are dependent variables, the variables themselves cannot covary in the structural equation model. Instead, I allowed their disturbances to covary.

The proposed model was tested in a systematic manner using the two-step model testing procedure (Anderson & Gerbing, 1988). Specifically, after confirming the factor structure of the variables in Research Questions 1-3, I developed and examined the fit of the measurement model that included all of the variables in this investigation. This was done separately for history and mathematics. Changes to improve model fit were made using the Lagrange Multiplier test if they were theoretically justifiable. Second, I assessed the proposed relations in Figure 1 by examining the fit of the structural model depicted in Figure 2. Additionally, using the Lagrange Multiplier test I made changes iteratively to improve the fit of the structural models. The fit of the structural model was assessed separately for history and mathematics. However, I descriptively compared the strength of the relations across domains using 95% confidence intervals.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this investigation was to assess the hypothesized model of the relations between students' domain-specific epistemological beliefs, competency beliefs (i.e., ability beliefs and expectancies for success), achievement values, reported strategy use, task performance, and future intentions. To accomplish this task, I examined the structure of students' domain-specific epistemological beliefs, competency beliefs, and achievement values using confirmatory factor analysis. I also employed structural equation modeling to assess those proposed relations (see Figure 1). These analyses were guided by four research questions. This chapter consists of four major sections, which present the analyses and results related to each of the four questions.

Structure of Students' Domain-Specific Epistemological Beliefs

The first research question in this investigation pertained to the structure of students' domain-specific epistemological beliefs. To address this question, I used EQS 5.7b to conduct a confirmatory factor analysis on the data from the history and mathematics epistemological belief items. I developed a six-factor model with factors that represented students' beliefs about the isolation of knowledge, the certainty of knowledge, as well as authority as the source of knowledge in history and mathematics. I also examined the correlations among the factors, tested the hypothesized factor structure against other models, and computed reliabilities for the data.

Development of a Six-Factor Epistemological Belief Model

For the initial epistemological belief confirmatory model, items were assigned to factors based on previous research (Buehl et al., 2002; Hofer, 2000). Table 17 presents the means and standard deviations for each of the items used to define the epistemological belief factors. Covariances were included among the six factors. Additionally, the item error variance terms of complementary history and mathematics items were allowed to covary across factors. Due to non-normality in the data (i.e., high kurtosis), I relied on robust fit statistics to determine model fit (e.g., Nevitt & Hancock, 2000). The fit of this initial model was considered poor due to a robust CFI value less than .96 (i.e., robust CFI = .82; SRMR = .080; robust RMSEA = .064; Satorra-Bentler χ^2 = 672.56; df= 225).

Due to the poor model fit, the Lagrange Multiplier test was used to suggest additional error to error covariance terms that might improve the fit of the model. Error to error covariances were only included if there was justification as to why the items may be related. For example, if the items contained similar wording (e.g., "Answers to questions in history change as experts gather more information" and "I am most confident that I know something in history when I know what the experts think") or if they addressed a similar belief (e.g., "Mathematics is unrelated to day-to-day life" and "Information learned in mathematics is useful outside of school"), error variances were allowed to covary. This process resulted in five additional error to error covariance terms. However, although these changes improved model fit, the robust CFI was still less than .96 (robust CFI = .88; SRMR = .073; robust RMSEA = .056; Satorra-Bentler χ^2 = 555.43; df = 220).

The low CFI suggested that the item to factor assignment was not appropriate and that the model needed additional respecification. Consequently, I used the Lagrange Multiplier test to suggest factor to item paths that would improve model fit. Specifically, the Lagrange Multiplier test indicated that Item 16, "If you read something in a history

Table 17

Means (Standard Deviations) of Items Used to Identify the Epistemological Belief Factors

	Domain			
	History		Mathematics	
Factor	Item	*M(SD)*	Item	*M(SD)*
Isolation of Knowledge	27	2.90 (2.20)	6	2.57 (2.44)
	29	2.01 (1.81)	36	2.63 (1.98)
	33	2.19 (1.92)	22	2.06 (1.86)
	34	2.52 (2.30)	18	2.47 (2.15)
Certainty of Knowledge	12	2.19 (1.85)	39	3.84 (2.29)
	15	2.79 (2.36)	38	4.36 (2.53)
	17	3.08 (2.40)	35	4.25 (2.40)
	19	2.91 (2.47)	20	5.09 (2.46)
Authority as the Source of Knowledge	16	2.58 (2.36)	28	4.67 (2.47)
	13	4.99 (1.99)	24	5.45 (2.16)
	37	4.03 (2.38)	23	5.81 (2.30)
	40	3.59 (2.35)	4	4.96 (2.38)

Note: Maximum score for all items is 9. Parallel history and mathematics items appear in the same row.

textbook, you can be sure it's true" (i.e., a Authority as the Source of History Knowledge belief item), was also related to the Certainty of History Knowledge belief factor. This item was assigned to the Certainty of History Knowledge factor and its complement in mathematics was assigned to the Certainty of Mathematics Knowledge belief factor. The original factor to item assignments for these items were also retained. Consequently, the two items each loaded on two factors.

I felt that this respecficiation was theoretically justifiable. That is, the items contained elements related to the certainty of knowledge and the extent to which knowledge came from an authority figure. Additionally, in Hofer's initial exploratory factor analysis (Hofer, 2000), these items double loaded on her Certainty/Simplicity of Knowledge and Source of Knowledge: Authority factors.

After respecifying the model using the Lagrange Multiplier test, the Wald test was used to remove seven non-significant error to error covariances. The fit of the final six-factor belief model was acceptable. Specifically, Hu and Bentler (1999) recommend the use of joint criteria to assess model fit. That is, for a model to be retained, one of the following sets of criteria must be met: CFI $\geq$ .96 and SRMR $\leq$ .10, or RMSEA $\leq$.06 and SRMR $\leq$ .10. The respecified six-factor model met the second set of criteria (i.e., RMSEA $\leq$.06 and SRMR $\leq$ .10; Table 18).

Correlations Among the Epistemological Belief Factors

Figure 3 visually displays the final item to factor assignment as well as the standardized path values. In confirmatory factor analysis, the standardized paths connecting the factors represent the correlations among the factors. To aid in the visual presentation of the information, Table 19 contains the correlations between the

Table 18

Fit Indices for the Six-, Three-, Two-, and One-Factor Epistemological Belief Models

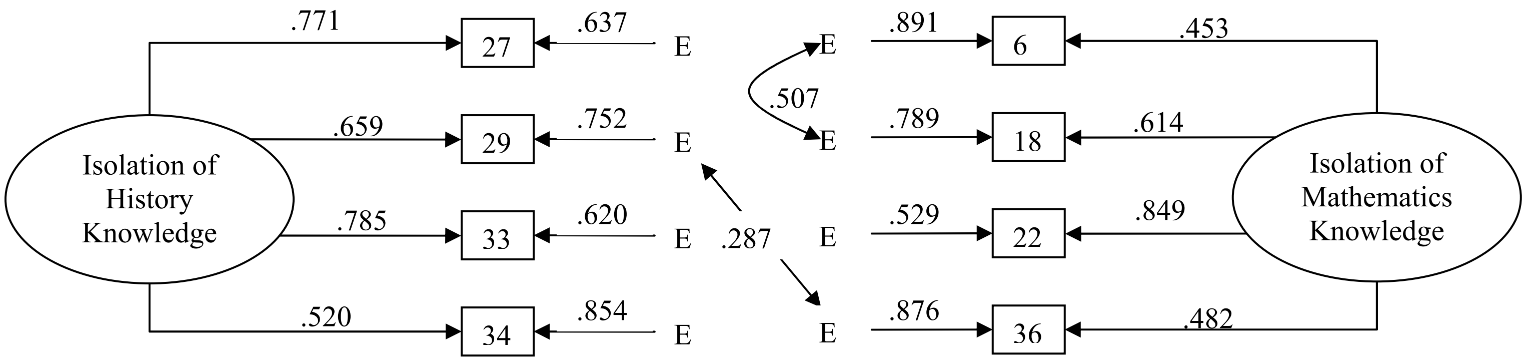
Model	Satorra-Bentler χ^2 (*df*) (χ^2)	Robust *CFI* (*CFI*)	*SRMR*	Robust *RMSEA* (*RMSEA*)
Six-Factor	515.66 (225)	.89	.068	.052
Domain Specific	(611.41)	(.88)		(.060)
One-Factor	1352.26 (242)	.59	.112	.098
Domain-General	(1625.97)	(.58)		(.109)
Two-Factor	1119.61 (241)	.68	.110	.087
Domain-Specific	(1319.85)	(.67)		(.096)
Three-Factor	983.51 (237)	.73	.095	.082
Domain-Specific	(1156.18)	(.72)		(.090)

epistemological beliefs factors. These correlations indicated that although some aspects of students' epistemological beliefs were related, others were not. For instance, there were significant positive correlations between the three history epistemological belief factors (i.e., Isolation of History Knowledge, Certainty of History Knowledge, and Authority as the Source of History Knowledge). The mathematics epistemological belief factors also tended to be significantly positively related (Table 19).

The one exception to this was a non-significant relation between the Isolation of Mathematics Knowledge and Authority as the Source of Mathematics Knowledge factors. Additionally, there were significant positive relations between the factors that addressed similar beliefs across domains (e.g., Isolation of History Knowledge and

Figure 3

Item Loadings, Error Terms, and Error Covariances of the Six-Factor Belief Model



(continued)

Figure 3 (continued)

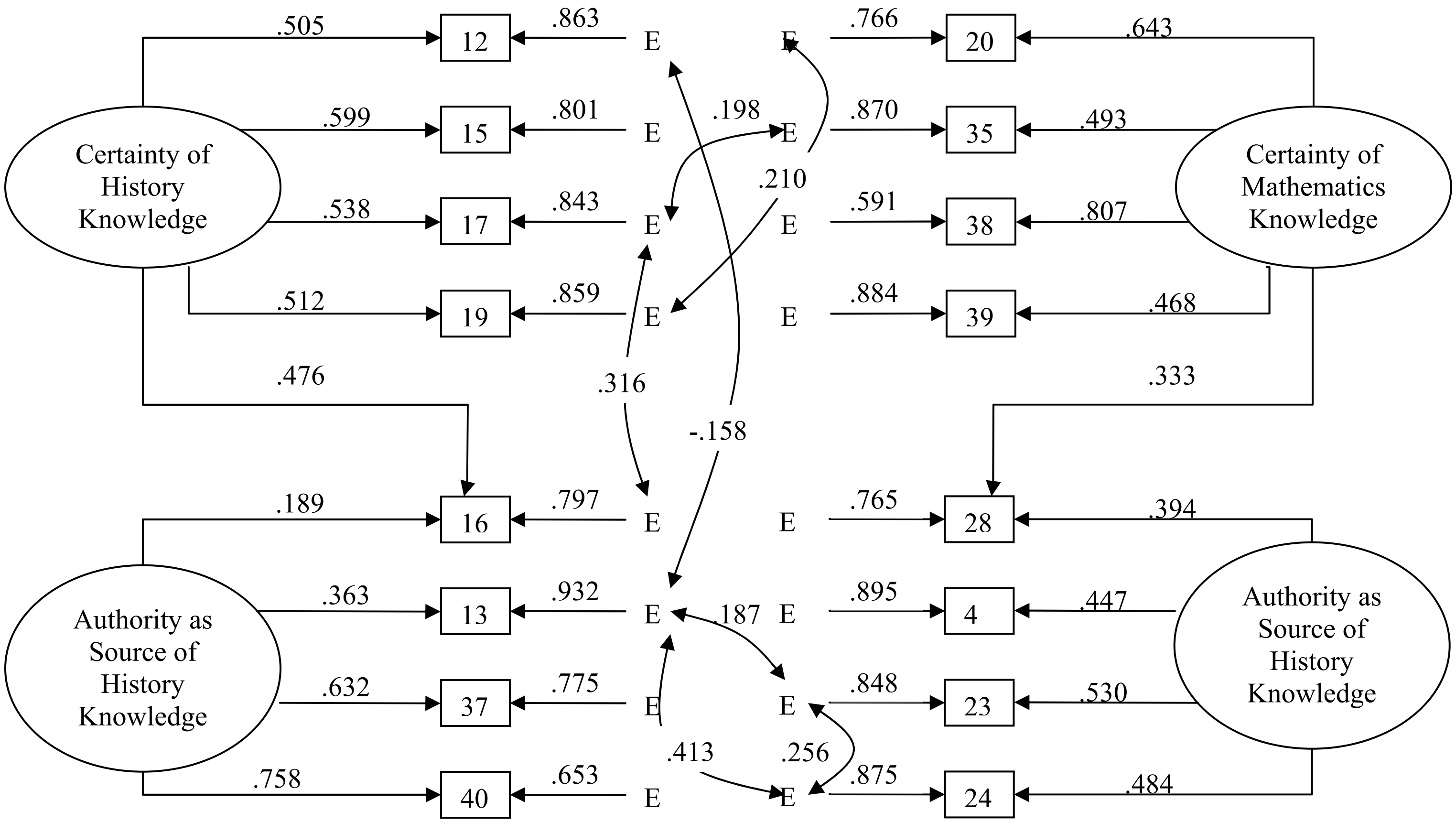


Table 19

Correlations Between History and Mathematics Epistemological Belief Factors

Factor	1.	2.	3.	4.	5.	6.
1. History Isolation	---					
2. History Certainty	.523**	---				
3. History Authority	.255**	.577**	---			
4. Mathematics Isolation	.438	.444**	.133*	---		
5. Mathematics Certainty	.288**	.377**	.206**	.221**	---	
6. Mathematics Authority	.003	.219**	.703**	-.072	.569**	---

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

Isolation of Mathematics Knowledge). These positive correlations within and across domains suggested that aspects of students' beliefs are interrelated and may form complex belief systems.

There were also epistemological belief factors that were not significantly related. For example, beliefs about the isolation of knowledge in one domain (e.g., history) were not significantly related to beliefs about authority as the source of knowledge in the opposing domain (e.g., mathematics). These findings provide further evidence that epistemological beliefs are multidimensional and domain-specific.

Testing Alternative Models

One of the benefits of using confirmatory factor analysis is the opportunity to test a model against other models. To provide further support for the multidimensional and domain-specific perspective of epistemological beliefs reflected in the six-factor epistemological belief model, I examined the fit of this model in relation to three other plausible models. The first model represented a unidimensional model of epistemological beliefs (i.e., all items assigned to a single factor). The second alternative model reflected a unidimensional, domain-specific view of epistemological beliefs (i.e., a history knowledge belief factor and a mathematics knowledge belief factor). The final model represented a multidimensional, domain-general view of epistemological views (i.e., single factors related to the isolation, certainty, and source of knowledge). The alternative models did not fit the data well (Table 17). That is, the robust CFI was less than .96 and the RMSEA was greater than .06 for the alternative models.

These findings indicated that the six-factor model was a plausible representation of students' epistemological beliefs. This model supports the multidimensional and domain-specific views of epistemological beliefs. However, the double assignment of three items suggested that the items used in this investigation did not clearly address a single epistemological belief factor. Additionally, only three aspects of students' knowledge beliefs were assessed.

Reliability of Epistemological Belief Factors

After verifying the assignment of items to factors, I calculated the construct reliability for each factor (Hancock, 2001; Hancock & Mueller, 2001). For history, the construct reliability coefficients for the Isolation of Knowledge factor was .81, Certainty of Knowledge .66, and Authority as the Source of Knowledge .65. For mathematics, the Isolation of Knowledge factor had a construct reliability coefficient of .79, Certainty of Knowledge .77, and the Authority as the Source of Knowledge had a reliability of .53. Overall, the reliabilities of the data were acceptable. However, the reliabilities for the

Authority as the Source of Knowledge factors were somewhat low. Although this may be partially attributable to the low number of items, this aspect of students' belief systems has been problematic in previous studies (e.g., Schommer, 1990).

Structure of Students' Competency Beliefs

The second research question in this investigation pertained to the structure of undergraduates' ability beliefs and expectancies for success relative to history and mathematics. In their work, Eccles and Wigfield (e.g., Eccles et al., 1983; Wigfield & Eccles, 2000) differentiated between students' beliefs about their abilities based on past performance (i.e., ability beliefs) and students' beliefs about their performance on future tasks (i.e., expectancies for success). However, in empirical studies with elementary, middle-school, and high-school students, items designed to assess ability beliefs and expectancies for success loaded on the same factor (e.g., Eccles & Wigfield, 1995; Eccles et al., 1993).

The current investigation was designed, in part, to determine if items related to college students' ability beliefs and expectancies for success differentiated empirically. To assess this, I used confirmatory factor analysis to test a four-factor model of students' ability beliefs and expectancies for success relative to history and mathematics. Similar to the beliefs data, there was non-normality (i.e., high kurtosis) in students' ability and expectancy responses. Consequently, I relied on robust fit indices and test statistics. Additionally, I examined the correlations among the factors, the fit of the four-factor model in relation to alternative models, as well as the reliabilities of the factors.

Table 20

Means (Standard Deviations) of the Items Used to Identify the Ability and Expectancy Belief Factors

	Domain			
	History		Mathematics	
Factor	Item	*M(SD)*	Item	*M(SD)*
Ability Beliefs	2	5.14 (2.14)	11	4.66 (2.50)
	18	5.34 (1.99)	9	5.11 (2.40)
	28	5.33 (2.27)	46	4.90 (2.49)
	41	5.31 (2.26)	14	5.23 (2.29)
Expectancy Beliefs	6	5.30 (2.09)	34	4.98 (2.29)
	10	5.57 (1.99)	44	4.76 (2.30)
	20	4.77 (2.46)	5	4.21 (2.73)
	26	5.60 (2.18)	17	5.33 (2.21)

Note: Maximum score for all items is 9. Parallel history and mathematics items appear in the same row.

Developing a Four-Factor Model of Ability Beliefs and Expectancies for Success

For the confirmatory factor model of students' ability beliefs and expectancies, I assigned items from the two domains to separate factors related to students' beliefs about their current ability and to students' beliefs about their performance on future tasks. The means and standard deviations for these items are presented in Table 20. Covariance terms were included among the four factors to allow them to covary. Additionally, error terms from each history and mathematics item pair were allowed to covary due to the similarity in the items across domains. The fit of this model was good (robust CFI = .97; SRMR = .042; robust RMSEA = .069; Satorra-Bentler χ^2 = 298.76 df = 90).

Despite the goodness of fit, the Lagrange Multiplier test was employed to suggest additional error to error covariance terms that may have improved the fit of the model. Modifications were made only if they were theoretically justifiable. For instance, the test suggested that adding an error covariance term between Items 9 and 34 (i.e., "In comparison to other undergraduate in your major, how good are you at mathematics?" and "Compared to other undergraduates in your major, how well would you expect to do on a college mathematics test?"). This addition was made because both items contained social comparisons. Using the Lagrange Multiplier test iteratively, two error covariance terms were added to the model. The Wald test was also used to remove six error covariance terms that were not statistically significant. After making these respecifications, the model fit was good (Table 21).

Correlations Among Factors

Because ability beliefs and expectancies for success did not differentiate empirically in the Eccles and Wigfield work, I was particularly interested in the correlations among the factors. Figure 4 displays the standardized paths for the history and mathematics ability beliefs and expectancies for success items. The correlations presented in Table 22 indicated extremely strong positive relations between ability beliefs and expectancies for success factors within history and mathematics, respectively (i.e.,

Table 21

Fit Indices for the Four-Factor, Two-Factor, and One-Factor Ability and Expectancy Models

Model	Satorra-Bentler χ^2 (*df*) (χ^2)	Robust *CFI* (*CFI*)	*SRMR*	Robust *RMSEA* (*RMSEA*)
Four-Factor	216.60 (94)	.99	.041	.052
Domain-Specific	(273.61)	(.98)		(.063)
One-Factor	3780.62 (100)	.64	.320	.253
Domain-General	(3801.62)	(.62)		(.277)
Two-Factor	3174.76 (99)	.64	.320	.254
Domain-General	(3798.49)	(.62)		(.279)
Two-Factor	227.52 (99)	.98	.043	.052
Domain-Specific	(285.98)	(.98)		(.063)

Table 22

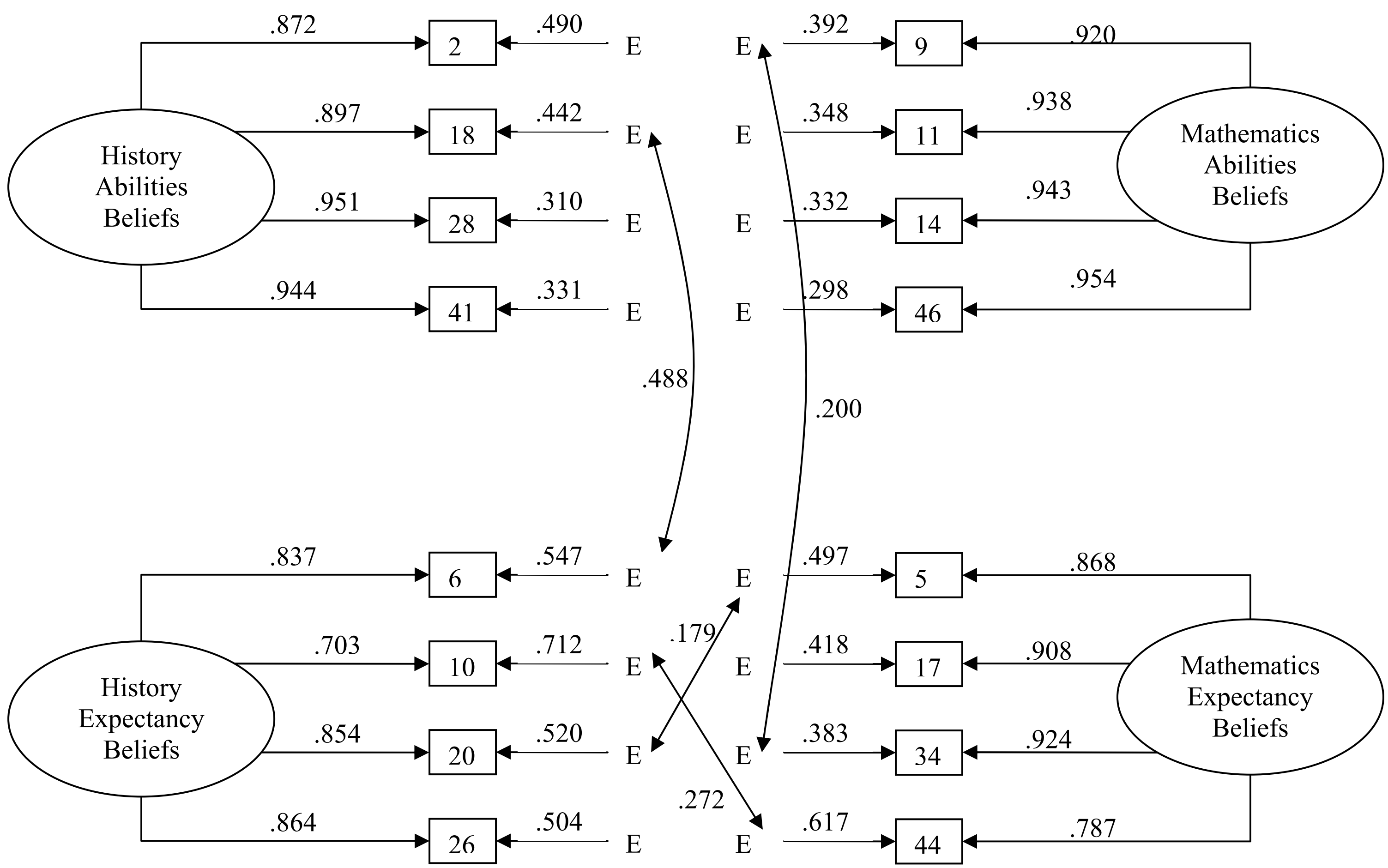
Correlations Between History and Mathematics Ability and Expectancy Belief Factors

Factor	1.	2.	3.	4.
1. History Ability Beliefs	---			
2. History Expectancy Beliefs	.996**	---		
3. Mathematics Ability Beliefs	-.203**	-.199**	---	
4. Mathematics Expectancy Beliefs	-.180**	-.165**	.991**	---

** $p < .01$

Figure 4

Item Loadings, Error Terms, and Error Covariances for the Four-Factor Ability/Expectancy Model



.991 and .996). The strength of these relations indicated that the factors may not be distinct.

Additionally, there were low, but significant, negative correlations between students' ability beliefs and expectancies across domains. These negative correlations suggested that students' beliefs about their abilities and their expectations to do well on future tasks in the two domains are inversely related. That is, students who had high levels of confidence in their mathematics abilities tended to have low levels of confidence in their history abilities. Students who expected to do well on future history tasks tended to not expect to do well on mathematics tasks.

Testing Alternative Models

Given the strong positive correlations between the ability and expectancy factors, it was important to test the four-factor model against alternative models. Consequently, the fit of the four-factor model was compared to the fit of three alternative models: a one-factor model (i.e., all of the items loading on a single factor), a two-factor domain-general model (i.e., ability belief items loading on one factor and expectancy items loading on a second factor), and a two-factor domain-specific model (i.e., history and mathematics loading on separate factors). As expected, the one-factor and two-factor domain-general models did not fit the data well (Table 21). However, the fit of the two-factor domain-specific model was comparable to the four-factor model (Table 21).

To determine which model was more appropriate, I relied on additional means of comparing model fit. For instance, a comparison of the robust CFI, SRMR, and robust RMSEA for the two models indicated that the four-factor model provided slightly better (i.e., at the thousandths level) fit than the two-factor model. Because the two-factor model was nested within the four-factor model, I was also able to compare the fit of the models using the change in chi-square test. This test determines if the change in the fit of two nested models was statistically significant. Due to the non-normality in the data, I relied on the robust chi-square change test recommended by Satorra and Bentler (2001). This test indicated that the change in the Satorra-Bentler chi-square was not statistically significant at the .05 level (Δ Satorra-Bentler $\chi^2 = 10.87$, $df = 5$, $p = .054$).

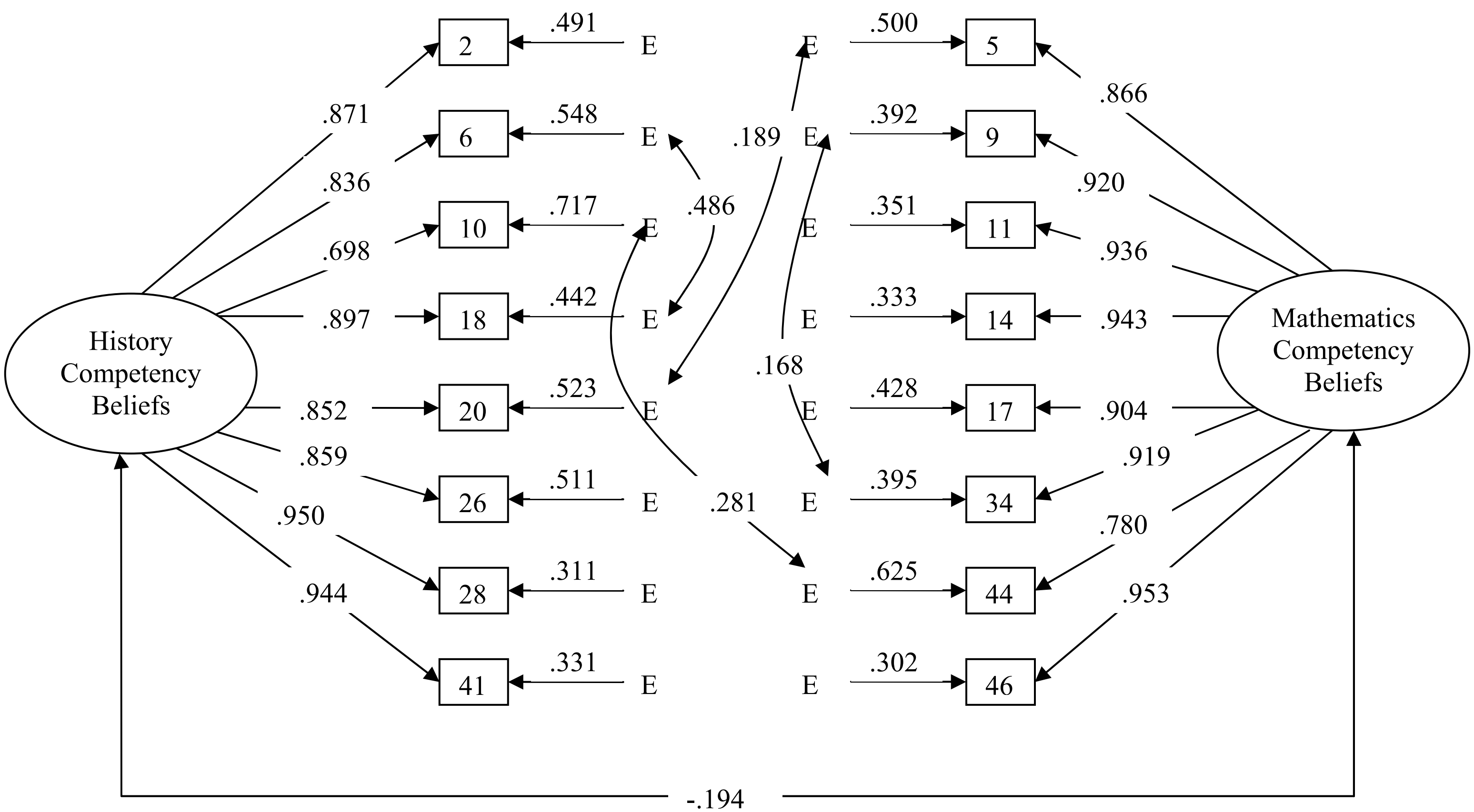
Based on the information provided by the various fit indices and model comparison techniques, I decided to adopt the two-factor model instead of the four-factor model that differentiated between ability beliefs and expectancies for success. The four-factor model fit the data well, providing support for the theoretical distinctions made by Eccles and Wigfield. However, the fit of this model was not statistically better than the fit of the two-factor model. In such situations, the more parsimonious model (i.e., the two-factor model) is recommended. Thus, these results confirmed the previous Eccles and Wigfield findings that ability beliefs and expectancies for success do not differentiate empirically. I hereto refer the combined ability and expectancy factors as students' competency beliefs. As seen in Figure 5, students' competency beliefs relative to history and mathematics were negatively related.

Reliabilities

After determining the appropriate factor structure, I examined the construct reliability of the factors using coefficient *H*. For history competency belief factor, the construct reliability coefficient was .97. The mathematics competency factor had a construct reliability of .98.

Figure 5

Item Loadings, Error Terms, and Error Covariances for the Two-Factor Competency Belief Model



Structure of Students' Achievement Values

In this investigation, the third research question pertained to the structure of students' achievement values. The expectancy-value model articulated by Eccles and Wigfield proposes that there are four aspects of achievement value (i.e., intrinsic, importance, utility, and cost value; Wigfield & Eccles, 1992). Studies with elementary, middle-school, and high-school students have consistently identified factors related to intrinsic value, importance value, and utility value. One of the purposes of this investigation was to examine the achievement values of college students. Further, I included items designed to tap into the cost value component.

Confirmatory factor analysis was used to assess the hypothesized structure of students' achievement values relative to history and mathematics. The correlations among the factors were analyzed and I compared fit of the hypothesized model of achievement values to alternative models. Reliabilities for the factors were also computed.

Development of an Eight-Factor Achievement Value Model

To develop an eight-factor model of students' achievement values relative to history and mathematics, items were assigned to the factors they were designed to assess. The means and standard deviations for these items are presented in Table 23. Covariances were included among the factors and error variance terms from complementary history and mathematics items were allowed to covary.

Due to non-normality in the data (i.e., high kurtosis), robust fit statistics were examined to determine the fit of the model to the data. These fit statistics indicated that the model fit the data well (robust CFI = .97; SRMR = .044; robust RMSEA = .050;

Table 23

Means (Standard Deviations) of the Items Used to Identify the Value Factors

	Domain			
	History		Mathematics	
Factor	Item	*M(SD)*	Item	*M(SD)*
Intrinsic	4	5.30 (2.57)	19	4.38 (2.75)
	23	4.65 (2.43)	38	4.58 (2.60)
	30	4.85 (2.46)	25	4.22 (2.54)
	47	4.58 (2.42)	13	5.65 (2.41)
Importance	15	6.06 (2.26)	39	6.07 (2.32)
	31	4.73 (2.23)	24	5.07 (2.36)
	35	5.34 (2.23)	1	6.04 (2.20)
	43	4.99 (2.27)	12	5.56 (2.22)
Utility	27	4.63 (2.32)	29	4.74 (2.36)
	32	4.34 (2.53)	45	4.87 (2.48)
	37	4.77 (2.27)	21	4.93 (2.30)
	42	5.02 (2.35)	8	5.30 (2.24)
Cost	3	5.86 (2.08)	16	5.69 (2.11)
	7	5.52 (2.10)	22	5.10 (2.27)
	36	5.26 (2.32)	48	3.63 (2.63)
	40	4.97 (2.25)	33	5.05 (2.19)

Note: Maximum score for all items is 9. Parallel history and mathematics items appear in the same row.

Satorra-Bentler $\chi^2 = 88.05$; df = 402). Further, the Lagrange Multiplier test did not suggest meaningful error to error covariance terms that would improve the fit of the model. The Wald test was used iteratively to delete eight non-significant error covariance terms that were initially included due to the complementary nature of the items in history and mathematics. The final eight-factor model of students' history and mathematics achievement values fit the data well (Table 24).

Table 24

Fit Indices for the Eight-, Four-, Two-, and One-Factor Achievement Value Models

Model	Satorra-Bentler χ^2 (*df*) (χ^2)	Robust *CFI* (*CFI*)	*SRMR*	Robust *RMSEA* (*RMSEA*)
Eight-Factor	895.27 (428)	.97	.044	.048
Domain-Specific	(1178.91)	(.96)		(.060)
One-Factor	7317.16 (456)	.54	.314	.177
Domain-General	(9636.99)	(.47)		(.205)
Two-Factor	1717.96 (455)	.92	.058	.076
Domain-Specific	(2356.42)	(.89)		(.093)
Four-Factor	7220.60 (450)	.54	.317	.177
Domain-General	(9090.77)	(.50)		(.200)
Two-Factor	63.06 (16)	.99	.037	.078
Composite	74.12	(.99)		(.087)

Correlations Among the Achievement Value Factors

The correlations between the factors are presented in Table 25 and Figure 6 presents the standardized path coefficients for the confirmatory factor model of students' history and mathematics achievement values. Based on this information, it is evident that students' valuing of history and mathematics were inversely related. That is, there were either low, negative correlations or non-significant correlations between the history and mathematics value factors. Thus, students who valued history tended to place less value on achievement in mathematics and students who placed a low value on history achievement tended to value mathematics more.

In contrast, the value factors within the respective domains were strongly positively related. Eccles and Wigfield also identified strong relations among different aspects of achievement value. Therefore, these strong positive correlations were anticipated. However, such correlations also suggested that the constructs may not be empirically distinct. Further, even if there was statistical support for differentiated factors, there may be multicollinearity problems if all of the factors were included in a structural equation model.

Assessing Alternative Models

The fit of the eight-factor model of students' history and mathematics achievement values was examined in relation to alternative models of achievement value. For instance, I computed the fit of a four-factor, domain-general model. Intrinsic value, importance value, utility value, and cost value items were assigned to separate factors irrespective of domain. This model did not fit the data well (Table 24). A one-factor model was also applied to the data and displayed poor fit (Table 24). Additionally, I

Table 25

Correlations Between History and Mathematics Achievement Value Factors

Factor	1.	2.	3.	4.	5.	6.	7.	8.
1. History Intrinsic	---							
2. History Importance	.901**	---						
3. History Utility	.821**	.942**	---					
4. History Cost	.936**	.979**	.909**	---				
5. Mathematics Intrinsic	-.221**	-.127*	-.184**	-.186**	---			
6. Mathematics Importance	-.155**	-.052	-.157**	-.112*	.879**	---		
7. Mathematics Utility	-.192**	-.093	-.167**	-.140**	.862**	.979**	---	
8. Mathematics Cost	-.096	.001	-.095	-.044	.882**	.978**	.945**	---

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

Figure 6

Item Loadings, Error Terms, and Error Covariances for the Eight-Factor Achievement Value Model

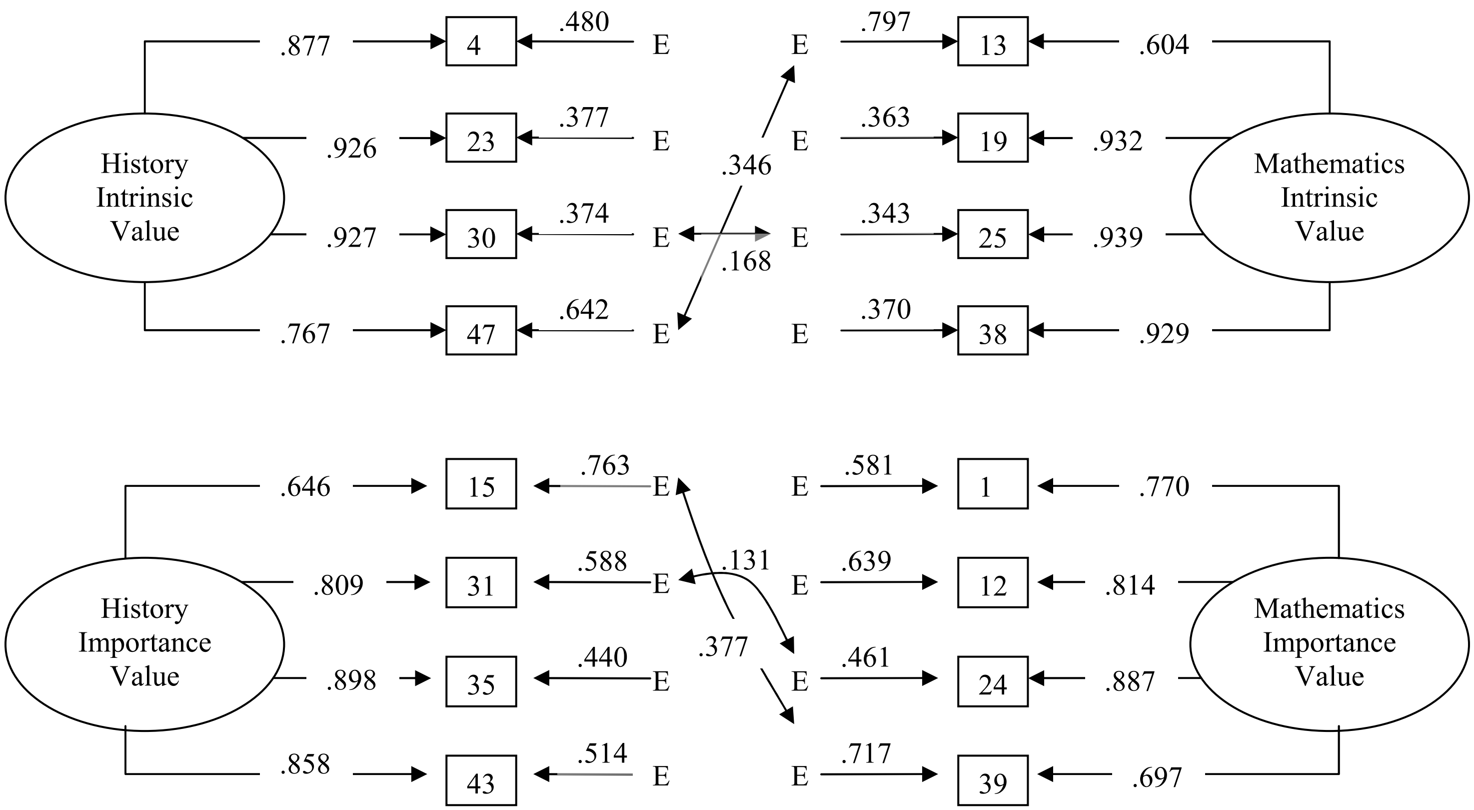


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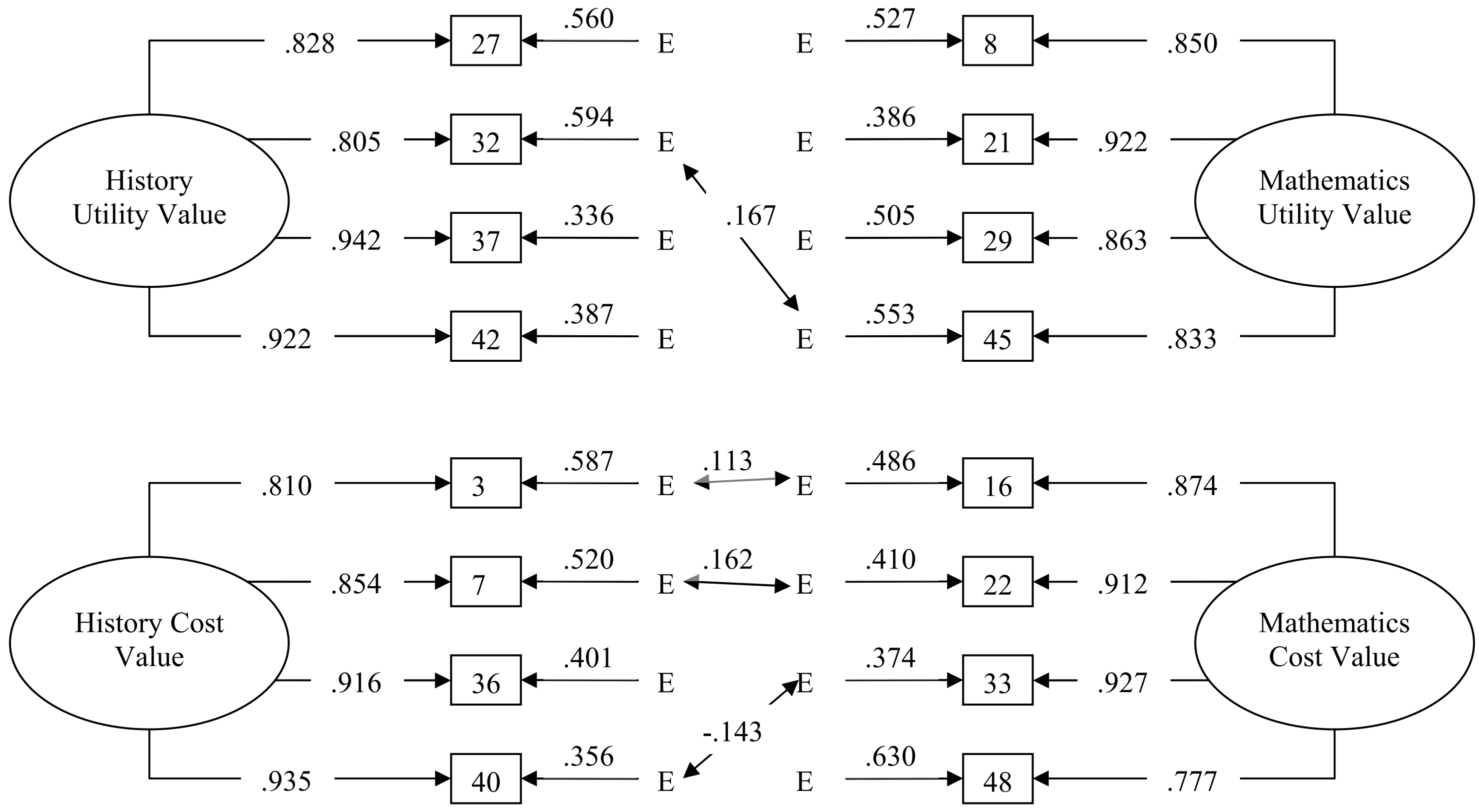
Figure 6 (continued)



analyzed the fit of a two-factor, domain-specific model in which the history value items were assigned to one factor and the mathematics value items were assigned to a second factor. This model had marginally good fit (Table 24). However, the change in the Satorra-Bentler χ^2 test indicated that the eight-factor model provided a significantly better fit (Δ Satorra-Bentler $\chi^2 = 284.14$, $df = 27$, $p < .05$). This indicated that although students' achievement values are related, they are empirically distinct.

In an effort to develop a simplified model of achievement value that could be used in a structural equation model without introducing problems of multicollinearity, I tested a final alternative achievement value model. Specifically, I created a composite for each value factor within each domain by summing the items and dividing by the number of items (i.e., four). The composite means and standard deviations are presented in Table 26. I then used the composite score for each aspect of value (e.g., intrinsic value) to identify a history achievement value and a mathematics achievement value factor. Covariances were included between factors and between the error terms of complementary composites (i.e., history utility value and mathematics utility value). This two-factor composite model fit the data well (robust CFI = .97; SRMR = .040; robust RMSEA = .134; Satorra-Bentler $\chi^2 = 144.92$; df = 15). Two additional error covariances were added iteratively at the suggestion of the Lagrange Multiplier test and three were removed based on the Wald test. The final two-factor, composite model fit the data well (Table 24).

The fit of the two-factor composite model could not be compared statistically to the eight-factor achievement value model because the models were not nested. However, descriptively, the two-factor composite model fit the data as well, if not better, than the eight-factor composite model. Further, the two-factor composite model eliminated

Table 26

Means (Standard Deviations) of Composites Used to Identify the Value Factors

	Domain	
	History	Mathematics
Value Composite	*M(SD)*	*M(SD)*
Intrinsic	4.85 (2.24)	4.71 (2.31)
Importance	5.28 (1.94)	5.69 (1.94)
Utility	4.69 (2.14)	5.29 (2.02)
Cost	5.40 (2.00)	4.87 (2.02)

Note: Maximum score for all composites is 9.

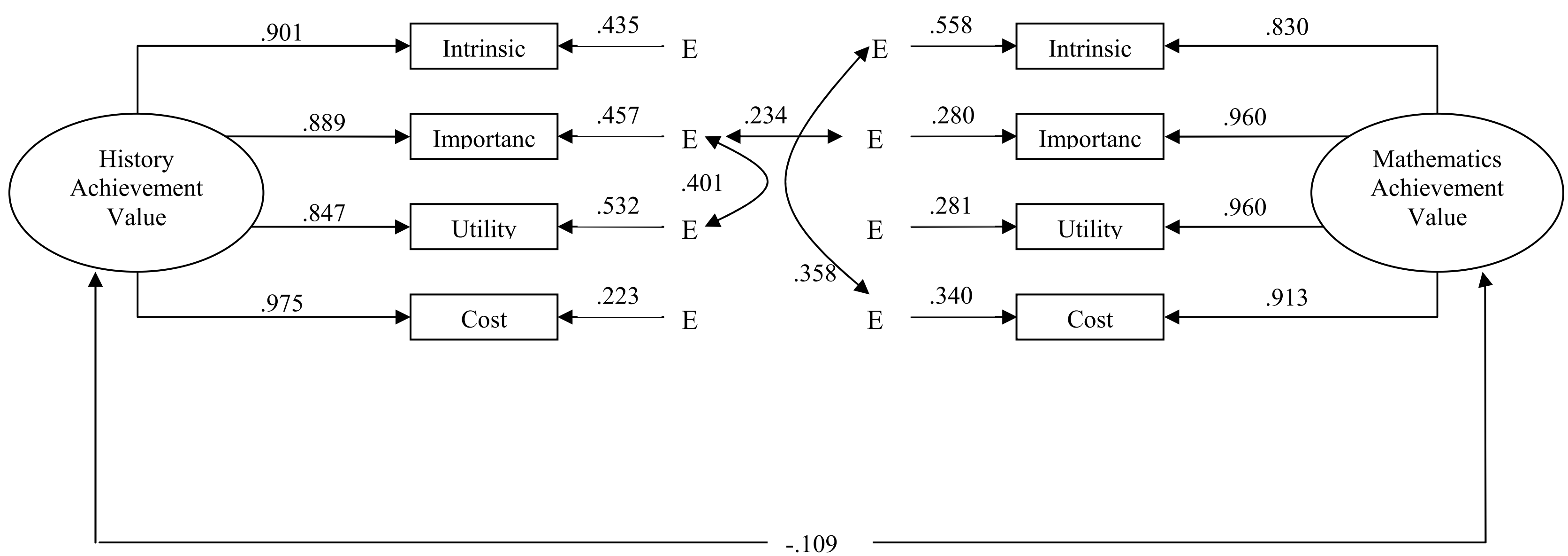
problems of multicollinearity. Consequently, for the structural equation modeling conducted for the final research question, I relied on the composite model of achievement value. The standardized solution for this model is presented in Figure 7.

Factor Reliabilities

In an effort to be thorough, I computed the construct reliabilities for the separate achievement value factors, as well as for the factors defined by the composite value scores. Specifically, the construct reliability coefficients for the history intrinsic value, importance value, utility value, and cost value factors were .94, .91, .95, and .94. Similarly, the construct reliabilities for the mathematics value factors were.95, .89, .93, and .94 for intrinsic value, importance value, utility value, and cost value, respectively.

Figure 7

Loadings, Error Terms, and Error Covariances for the Two-Factor Achievement Value Model Based on Value Composites



The construct reliability coefficients for the history and mathematics value factors defined by the composite scores were both .97. Further, because they factors were defined by composite scores, I calculated Cronbach's alpha for the data from the history intrinsic value(α=.93), importance value (α=.89), utility value (α=.93), and cost value (α=.93) items and the mathematics intrinsic value (α=.92), importance value (α=.87), utility value (α=.92), and cost value (α=.92) items.

Modeling the Relations Between Epistemological Beliefs, Motivation, and Achievement

The fourth and final research question pertained to the hypothesized model displayed in Figure 1 (see Chapter 1). This model depicts the relations between epistemological beliefs, achievement motivation, and learning outcomes. Given the complexity of the model, I assessed only a portion of it in this investigation. The hypothesized structural model I assessed is displayed in Figure 2 in Chapter 1. To assess the hypothesized structural model, I used the two-step process recommended by Anderson and Gerbing (1988). For the first step, I fit the measurement model to the data. For the second step, I applied the hypothesized structural model to the data.

More specifically, the initial measurement model was based on the results of Research Questions 1-3. Items and composites were assigned to factors in accordance with the previously developed models. Within-domain error to error covariances from the previous models were also included. Further, the three-strategy composite scores and the knowledge change scores were included as measured variables. Items designed to assess students' intentions to engage in history or mathematics activities in the future were assigned to the intentions factor. For the measurement model, all of the factors and measured variables were allowed to covary. After fitting the initial measurement model to the data, I used the Lagrange Multiplier test to add additional error to error covariances iteratively that were theoretically justifiable.

Next, I specified the paths indicated in the hypothesized structural model (see Figure 2) and examined the fit of the model. Additional structural paths were added iteratively to improve the model fit based on the Lagrange Multiplier test. The fit of the final structural model and thestandardized path coefficients were then interpreted. This process was conducted separately for the history and mathematics data.

Before conducting the structural equation modeling, several preliminary analyses were conducted. Consequently, I present the preliminary analyses, followed by separate sections on the history and mathematics structural models. I also include a section comparing the structural models for the two domains.

Descriptive Statistics and Preliminary Analysis

Differences in Knowledge Scores by Time and Domain

The means and standard deviations for the history and mathematics knowledge tests at pre-reading and post-reading are presented in Table 27. This table also presents the mean change score from pre-reading to post-reading for history and mathematics and indicates that students' knowledge increased from pre-reading to post-reading. To determine if there was a statistically significant change in students' knowledge from pre-reading to post-reading as well as if there were differences in students' performance on the history and mathematics knowledge tests, a repeated measure MANOVA was conducted with domain as a within-subject variable. That is, a 2 x 2 MANOVA (time x

Table 27

Means and Standard Deviations for the History and Mathematics Knowledge Tests

	Domain	
	History	Mathematics
Variable	*M* (*SD*)	*M* (*SD*)
Pre-Reading Knowledge Score	6.89 (2.51)	6.28 (2.34)
Post-Reading Knowledge Score	9.87 (3.09)	8.19 (2.93)
Knowledge Change Score	2.97 (2.55)	1.91 (2.39)

domain) was conducted with students' pre-reading and post-reading history and mathematics scores as the dependent variables.

This analysis revealed significant main effects for time [$F(1, 481)=115.77$, $p < .001$] and domain [$F(1, 481)=813.40$, $p < .001$], indicating that students performed better at post-reading than pre-reading (i.e., their knowledge scores increases) and that they performed better on the history tests than on the mathematics tests. Additionally, the time by domain interaction was statistically significant [$F(1, 481)=52.67$, $p < .001$]. To determine the nature of the interaction, paired t-tests were conducted comparing students' performance on the history and mathematics tests at pre-reading and post-reading as well as the change in students' scores from pre-reading to post-reading. These analyses revealed students' performed better on the history knowledge test than the mathematics knowledge test at both pre-reading [$t(481)=4.88$, $p < .001$] and post-reading

[$t(481)=12.73$, $p < .001$]. Further, the change in students' knowledge scores was statistically greater for history than mathematics [$t(481)=7.26$, $p < .001$].

These findings indicated that students were more knowledgeable about the content of the history portion of the text before reading. The results also demonstrated that students gained more from this section of the text, as compared with the mathematics portion of the text. However, because the data from the two portions of the text were to be modeled separately, this was not viewed as a major concern.

Relation Between Prior Experience and Knowledge Test Performance

In order to determine if students' prior experiences (i.e., previous mathematics and statistics classes) were related to their performance on the mathematics knowledge test, I examined the correlations between the number of college mathematics and statistics classes students had completed and their pre-reading mathematics knowledge score, post-reading mathematics knowledge score, and the change score from pre-reading to post-reading. As seen in Table 28, there were significant positive correlations between number of mathematics courses and performance on the pre-reading knowledge measure and between number of statistics courses and performance on the post-reading mathematics measure. However, these correlations were weak (i.e., $r \leq .11$) and most likely reached statistical significance because of the sample size.

Previous mathematics and statistics experience, as assessed by number of college classes, was not statistically related to the change in students' knowledge scores from pre-reading to post-reading. Consequently, although students' previous experiences with respect to mathematics and statistics was weakly related to some aspects of students'

Table 28

Correlations Between Mathematics and Statistics Experiences and Mathematics Test Performance (n = 482)

Variable	1.	2.	3.	4.	5.
1. Number of College Mathematics Courses	---				
2. Number of College Statistics Courses	.300**	---			
3. Pre-Reading Mathematics Knowledge Score	.099*	.053	---		
4. Post-Reading Mathematics Knowledge Score	.086	.107*	.609**	---	
5. Mathematics Knowledge Change Scores	.008	.080	.230**	.631**	---

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

performance on the knowledge measures, these relations appeared inconsequential for the current investigation. Thus, I included all of the students in the structural models, irrespective of previous experience.

Additional Descriptive Statistics

For the history and mathematics structural models, the epistemological belief, competency belief, and intentions factors were each identified by individual items, whereas the value factors were identified by composite scores. The means and standard deviations of the items identifying the epistemological belief and expectancy belief factors were previously presented in Tables 17 and 20 and the means and standard deviations for the value composites were presented in Table 23. Table 29 displays the means and standard deviations for the items used to define the intentions factors.

Reported strategy use and task performance were measured variables. The means and standard deviations for the reported strategy use composite scores are in Table 30. Table 27 presented the means and standard deviations for the knowledge change scores.

History Structural Model

For the history data, the initial measurement model fit the data well (Table 31). This fit was further improved by adding three error covariance terms iteratively, as suggested by the Lagrange Multiplier test (Table 31). The structural model was then applied to the history data. The hypothesized structural model fit the history data well (Table 31). The fit criteria I examined either met or exceeded the recommended levels. The goodness of fit for this model provided support for the hypothesized relations among the variables and the proposed theoretical model (Figure 1).

Table 29

Means (Standard Deviations) of Items Used to Identify the Intentions Factors

Domain			
History		Mathematics	
Item	*M(SD)*	Item	*M(SD)*
1	4.69 (3.01)	5	4.26 (3.09)
3	5.07 (2.80)	8	2.36 (2.63)
4	2.61 (2.76)	7	2.78 (2.91)
6	5.10 (2.82)	2	5.23 (2.29)

Note: Maximum score for all items is 9. Parallel history and mathematics items appear in the same row.

Table 30

Means (Standard Deviations) of Reported Strategy Use Composites

	Domain	
	History	Mathematics
Strategy Composite	*M(SD)*	*M(SD)*
Surface-Level	0.56 (0.39)	0.47 (0.44)
Moderate-Level	0.56 (0.43)	0.58 (0.35)
Deep-Processing	0.67 (0.51)	0.66 (0.60)

Note: Maximum score for all composites is 2.

Despite the goodness of fit, I decide to employ the Lagrange Multiplier test to identify potential relations that were not included in the original hypothesized model. The test suggested that the addition of a path from students' competency beliefs to their intentions would improve model fit significantly. Although this path was not included in the hypothesized model, I felt that it was theoretically justified. That is, a student's beliefs about his competency for history tasks may influence his intentions to pursue additional activities in the domain. After modifying the structural model to include this path, the model fit the data well and no additional paths were suggested (Table 31).

Table 31

Fit Indices for Assessing the Hypothesized Structural Model with the History Data

Model	Satorra-Bentler χ^2 (*df*) (χ^2)	Robust *CFI* (*CFI*)	*SRMR*	Robust *RMSEA* (*RMSEA*)
Initial Measurement	867.60 (418)	.95	.055	.047
	(986.07)	(.95)		(.053)
Final Measurement	802.54 (414)	.96	.056	.044
	(909.33)	(.95)		(.050)
Initial Structural	836.67 (429)	.96	.057	.044
	(944.34)	(.95)		(.050)
Final Structural	827.75 (428)	.96	.057	.044
	(934.58)	(.95)		(.050)

The final structural model with standardized path coefficients is displayed in Figure 8. Due to non-normality in the data, robust test statistics were used to determine if paths were statistically significant. As seen in Figure 8, some of the predictions about the relations between students' epistemological beliefs, motivation, intentions, and performance were upheld and others were not.

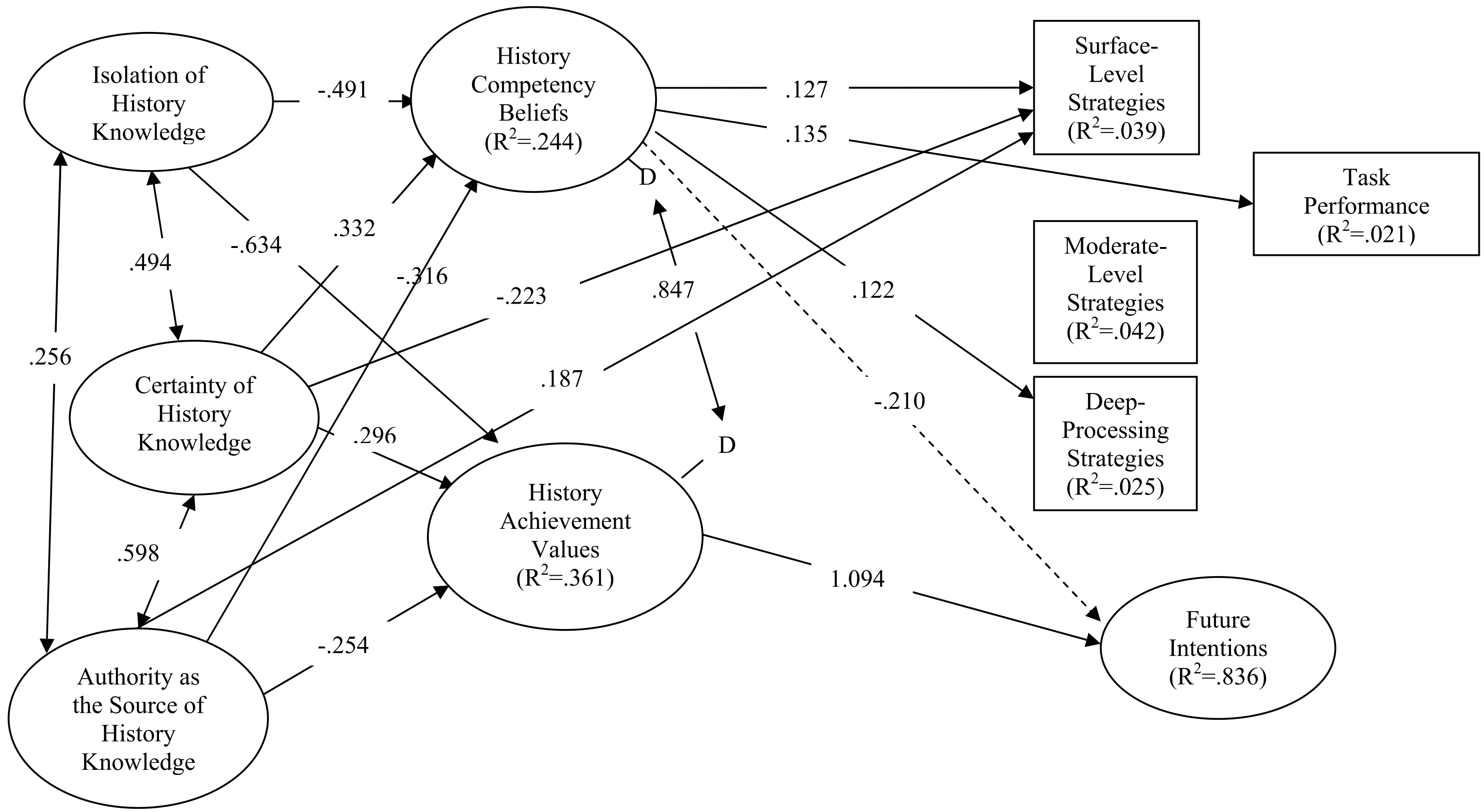
Direct Paths from Epistemological Belief Factors

First, with respect to epistemological beliefs, the three belief factors were significantly positively related to one another as anticipated. Additionally, the three history knowledge belief factors significantly influenced students' history competency beliefs and achievement values. In particular, students' beliefs about the isolation of history knowledge and authority as the source of history knowledge negatively affected competency beliefs and achievement values. Because of how the epistemological belief items were scored, these negative relations were expected. That is, higher scores were indicators of more naïve epistemological beliefs. Consequently, these relations implied that a decreased belief in the isolation and simplicity of knowledge or a decreased belief in the stance that knowledge comes from authority resulted in students' expression of greater confidence in their abilities to do well in history and an increase in the extent to which students valued history.

In contrast, there was a positive direct path between the Certainty of History Knowledge factor and competency beliefs and achievement values in history. The direction of this relation was the reverse of the hypothesized path. That is, the positive

Figure 8

Standardized Structural Model for the History Data



Note. For all included paths, $p < .05$. Solid lines indicate hypothesized paths. Dotted lines indicate paths added using the Lagrange Multiplier test.

path value suggested that students who viewed history knowledge as uncertain and tentative expressed lower levels of confidence with respect to their abilities to do well in history and tended to value history less.

Two of the epistemological belief factors were also related to students' use of strategies. Specifically, beliefs about the certainty of history knowledge negatively predicted the use of surface-level strategies and beliefs about authority as the source of history knowledge positively predicted surface-level strategy use. The negative path between the Certainty of Knowledge factor and Surface-Level Strategy Use indicated that students who viewed knowledge as more certain and static used fewer surface-level strategies when reading and learning from text. Alternatively, students who viewed knowledge as more tentative and uncertain used more surface-level strategies as they read. The positive path between Authority as the Source of Knowledge and Surface-Level Strategy Use indicated that when students believed knowledge is passed down from an authority figure, they tended to use more surface-level strategies to acquire the knowledge. Students who placed less emphasis on the role of authority used fewer surface-level strategies.

The epistemological belief factors were not related to the other forms of students' reported strategy use (i.e., moderate and deep-processing). This finding contradicted previous work in which epistemological beliefs were significantly related to the number and sophistication of the strategies students use (e.g., Kardash & Howell, 2000). Upon reflection, I felt that these non-significant findings may be due to the reliabilities of the strategy variables. The reliabilities were relatively low, possibly hindering the emergence of significant relations with other constructs and measures.

Direct Paths from the Motivation Factors

The two motivation variables that were included in the model were students' competency beliefs and achievement values. Overall, the predictions related to the motivation constructs were upheld. For instance, competency beliefs and achievement values were positively related, as indicated by the positive correlation among the factors' disturbances. That is, because competency beliefs and achievement values were dependent variables, it was not possible for them to be correlated directly in the structural equation model. However, their disturbance (i.e., error terms for factors) can be related. This significant relation between competency beliefs and achievement value has been identified in previous works (e.g., Meece et al., 1990).

As anticipated, competency beliefs significantly positively influenced the use of surface-level and deep-processing strategies and predicted increases in students' knowledge from pre-reading to post-reading. These results supported previous findings regarding the relations between students' competency beliefs, strategy use, and performance (e.g., Zimmerman & Martinez-Pons, 1990).

Students' valuing of history positively influenced their intentions to engage in history activities in the future, replicating findings by Meece et al. (1990). Further, based on an addition suggested by the Lagrange Multiplier test, there was a negative correlation between students' competency beliefs and their intentions to engage in future history tasks. This path was not included in the hypothesized model and is in the opposite direction than expected. That is, the negative path coefficient indicated that students who believed they would perform well in history tasks were less likely to want to participate in history learning activities.

Non-Significant Relations Between Reported Strategy Use and Knowledge Change

For the history structural model, reported strategy use did not significantly predict a change in students' knowledge from pre-reading to post-reading. However, the proposed model hypothesized that these variables would be related. Further, multiple programs of research have provided evidence of the relation between strategy use and performance (e.g., Pressely et al., 1992).

Mathematics Structural Model

I employed similar procedures to those just described for the mathematics data. First, the initial measurement model was specified using the procedures previously described. The model fit the data well (Table 32). The robust CFI was greater than .96 and the SRMR and robust RMSEA were less than .10 and .60, respectively. Second, in an effort to improve the model fit, four error to error covariances were iteratively added to the model. The respecifications improved the fit of the model (Table 32). Third, I fit the hypothesized structural model to the data. This model also fit the data quite well (Table 32). This finding, in conjunction with the results from the history model, provides additional evidence of the viability of the hypothesized model.

However, as before, the Lagrange Multiplier test was used to determine if additional relations existed among the variables. The test suggested the addition of two structural paths, which were added to the model iteratively. Specifically, a path was included from the Isolation of Mathematics Knowledge factor to the Intentions factor and from the Authority as the Source of Mathematics Knowledge factor to the Intentions factor. The fit statistics for the final structural model are displayed in Table 32 and the

Table 32

Fit Indices for Assessing the Hypothesized Structural Model with the Mathematics Data

Model	Satorra-Bentler χ^2 (*df*) (χ^2)	Robust *CFI* (*CFI*)	*SRMR*	Robust *RMSEA* (*RMSEA*)
Initial Measurement	928.38 (418)	.95	.044	.050
	(1055.62)	(.94)		(.057)
Final Measurement	815.68 (413)	.96	.041	.045
	(925.44)	(.96)		(.051)
Initial Structural	851.86(428)	.96	.043	.045
	(964.99)	(.95)		(.051)
Final Structural	836.56 (426)	.96	.042	.045
	(947.06)	(.96)		(.050)

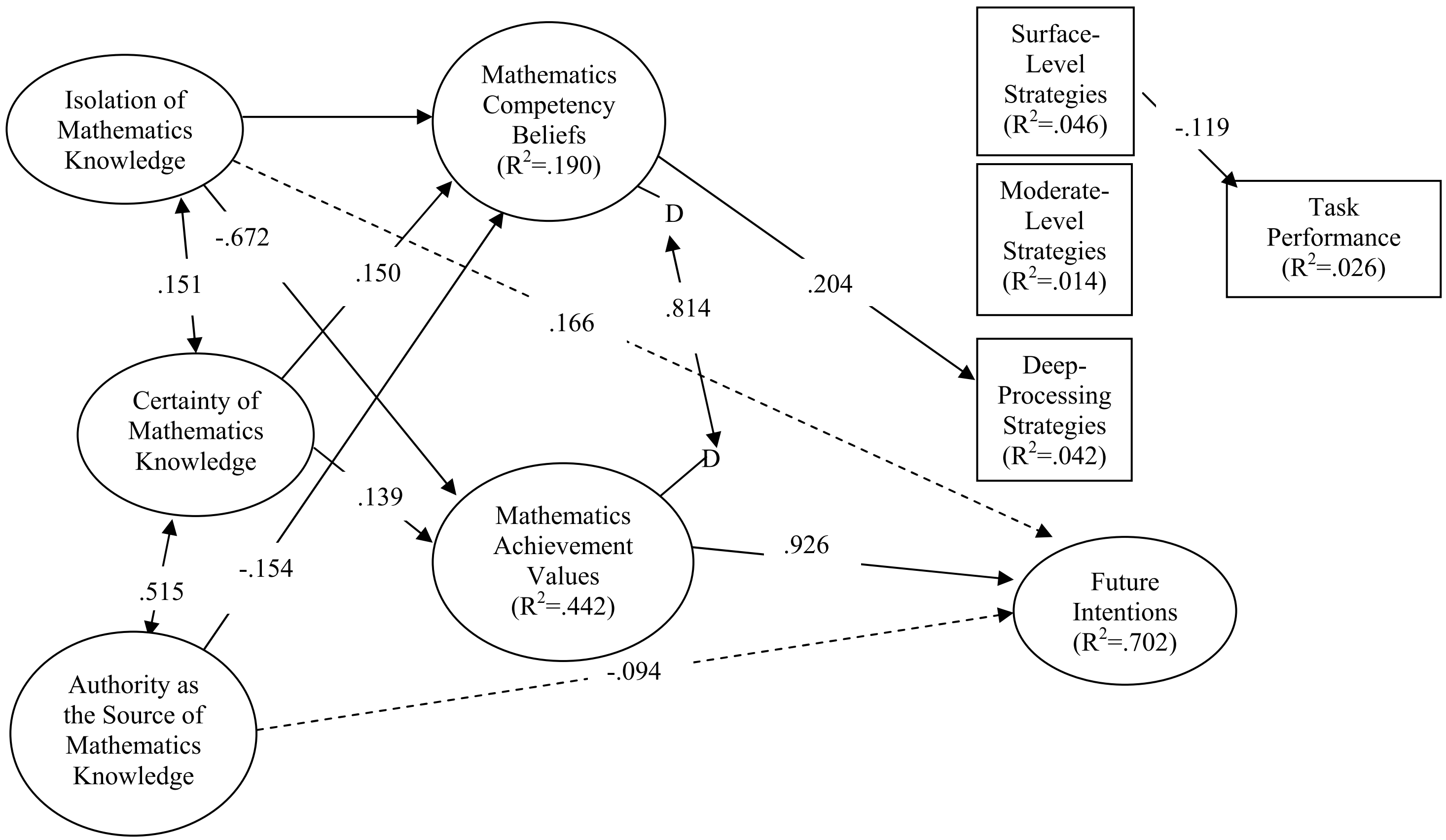
standardized structural equation model for the mathematics data is presented in Figure 9. Similar to the model for the history data, many of the hypothesized relations were upheld. However, there were several predictions that were not supported by the data.

Direct Paths from Epistemological Beliefs

With respect to epistemological beliefs, the Isolation of Mathematics Knowledge and Certainty of Mathematics Knowledge factors, and the Certainty of Mathematics Knowledge and Authority as the Source of Mathematics Knowledge factors were

Figure 9

Standardized Structural Model for the Mathematics Data



Note. For all included paths, $p < .05$. Solid lines indicate hypothesized paths. Dotted lines indicate paths added using the Lagrange Multiplier test.

significantly positively related. However, the covariance between the Isolation of Mathematics Knowledge and the Authority as the Source of Mathematics Knowledge factors was not statistically significant. This non-significant relation was unanticipated.

Despite the non-significant relation between the two mathematics epistemological belief factors, students' knowledge beliefs relative to mathematics were related to their achievement motivation in a manner similar to history. Specifically, beliefs about the isolation of mathematics knowledge negatively influenced mathematics competency beliefs and achievement value. In effect, the less students viewed mathematics knowledge as isolated, the more confidence they had in their mathematics abilities and the more they valued mathematics achievement. Additionally, beliefs about authority as the source of mathematics knowledge were negatively related to competency beliefs. Further, beliefs about the certainty of mathematics knowledge positively predicted students' mathematics competency beliefs and achievement values. These significant paths replicated the findings for history data.

However, the path between students' beliefs about the source of mathematics knowledge and their achievement values was non-significant, and students' mathematics epistemological beliefs were not related to their reported strategy use. Further, two statistically significant paths emerged that were not anticipated. For one, students' beliefs about the isolation of mathematics knowledge positively predicted their intentions to engage in mathematics tasks. This indicated that the more students believed mathematics exists in isolation, the more likely they were to want to engage in mathematics-related activities. In contrast, students' beliefs about authority as the source of mathematics knowledge negatively influenced their desire to engage in mathematics, suggesting that the less students viewed mathematics knowledge as being handed down from an authority figure, the more likely they were to want to participate in mathematics learning activities. These respective non-significant and significant paths were not expected and, thus, represent deviations from the hypothesized model.

Direct Paths from Motivation Constructs

With respect to students' achievement motivation, some predictions were upheld, while others were not. For instance, students' competency beliefs and achievement values were significantly related as indicated by the positive relation between their respective disturbances. Additionally, as hypothesized, achievement values significantly predicted students' intentions to engage in mathematics-related activities in the future. However, the hypothesis that competency beliefs would predict increases in mathematics knowledge was not upheld. Further, students' competency beliefs were related to only one aspect of their reported strategy use (i.e., deep-processing strategies).

Direct Path from Reported Strategy Use to Knowledge Gains

As seen in Figure 9, the only variable that was significantly related to students' mathematics learning was surface-level strategy use. The negative path between these variables suggested that students who used surface-level processing strategies (e.g., skipping information) did not significantly increase their mathematics knowledge from pre-reading to post-reading. Further, although several paths approached significance, the other variables in the model were not statistically related to students' surface-level strategy use.

Comparison of the History and Mathematics Models

The final structural models for history and mathematics (Figures 8 and 9) were compared visually to determine if the relations between the variables varied across domains. Additionally, to determine if path values in the two models were similar, I constructed confidence intervals around the path values that were statistically significant in one or both of the structural models (i.e., history and or mathematics; Table 33). These confidence intervals allowed me to compare the paths across domain. Confidence intervals that overlap indicate that the path values are similar. In contrast, if the confidence intervals do not overlap, this is evidence that the strength and nature of the relation between the variables differs across domain. These comparisons revealed that many of the relations were similar for history and mathematics. However, there were also certain differences.

Factor to Factor Covariance Paths

In the proposed model, epistemological beliefs are hypothesized to be related to one another. Overall, this hypothesis was supported. Specifically, beliefs about the isolation of knowledge and the certainty of knowledge and beliefs about the certainty of knowledge and authority as the source of knowledge were significantly related in each domain. Further, although the confidence intervals overlapped, the path between the Isolation of Knowledge and Authority as the Source of Knowledge factors was statistically significant for history, but not mathematics. This suggests that the relation is similar across domains. However, the history and mathematics confidence intervals for the Isolation of Knowledge and Certainty of Knowledge belief factors do not overlap,

Table 33

Confidence Intervals (95%) for Significant Paths in the History and Mathematics Structural Models

	Domain	
Type of Path	History	Mathematics
Path (From, To)	lower bound, upper bound	lower bound, upper bound
Factor to Factor Covariance Paths		
Isolation, Certainty[§]	.794, 1.464	.065, .641
Isolation, Authority	.093, .395	-.253, .295*
Certainty, Authority	.209, .655	.571, 1.281
Direct Paths		
Isolation, Competency	-.683, -.373	-.874, -.462
Isolation, Value	-.943, -.599	-1.545, -.700
Certainty, Competency	.154, .782	.026, .426
Certainty, Value	.153, .791	.025, .347
Certainty, Surface-Level Strategy Use	-.124, -.006	-.076, .006*

Note: * indicates paths that were not statistically significant. [§] indicates confidence intervals that did not overall (i.e., the path values are not similar).

(continued)

Table 33 (continued)

Type of Path	Domain	
	History	Mathematics
Path (From, To)	lower bound, upper bound	lower bound, upper bound
Direct Paths		
Authority, Competency	-1.865, -.281	-.603, -.016
Authority, Value	-1.739, -.211	-.424, .022*
Authority, Surface-Level Strategy Use	.007, .257	-.002, .128*
Competency, Surface-Level Strategy Use	.002, .050	-.041, .003*
Competency, Deep-Processing Strategy Use	.001, .064	.026, .080
Competency, Task Performance	.069, .301	-.050, .130*
Value, Intentions	1.173, 1.525	1.084, 1.324
Surface-Level Strategy Use, Task Performance	-.911, .233*	-1.106, -.188
Disturbance to Disturbance Covariance Paths		
Competency, Value	1.858, 2.760	2.137, 3.191

Note: * indicates paths that were not statistically significant. § indicates confidence intervals that did not overall (i.e., the path values are not similar).

indicating that the relation between beliefs about the isolation of knowledge and the certainty of knowledge is stronger in the domain of history than it is in mathematics.

Direct Paths: Epistemological Beliefs, Competency Beliefs, and Achievement Values

With respect to the proposed relations between students' epistemological beliefs, competency beliefs, and achievement values, evidence suggested that beliefs about the isolation and certainty of knowledge had similar influences on students' competency beliefs and achievement values in the respective domains. There were also similar relations between beliefs about authority as the source of knowledge and competency beliefs. That is, the paths were statistically significant in both domains and the confidence intervals overlapped. The primary difference with respect to the relations between epistemological beliefs and motivation across domains pertained to the relation between students' beliefs about authority as the source of knowledge and achievement value. This relation was statistically significant for history, but not for mathematics. However, in the mathematics model the influence of authority beliefs on achievement value approached statistical significance. Additionally, the confidence interval for the path coefficients in each domain overlapped, indicating similarities across domain.

Direct Paths: Epistemological Beliefs and Strategy Use

The hypothesized model also proposed that students' epistemological beliefs would influence their strategy use. There was inconclusive evidence about the nature and strength of this relation. Specifically, direct paths between the epistemological belief factors and reported strategy use variables were only statistically significant in the history model. Further, in the history model, students' beliefs about the certainty and source of knowledge only significantly predicted their use of surface-level strategies. Although these paths were not statistically significant in the mathematics model, the path values approached statistical significance and were in the same direction (e.g., beliefs about the certainty of knowledge and surface-level strategy use were negatively related) as the paths in the history model. Additionally, the confidence intervals for the path coefficients overlapped, suggesting the paths were similar across domains. This offers some support for the hypothesized paths. However, the lack of relations between the epistemological beliefs factors and the other forms of strategy use disconfirms the hypothesized relations.

Direct Paths: Achievement Motivation, Strategy Use, Task Performance, and Future Intentions

With respect to achievement motivation, the hypothesized model suggested that students' competency beliefs would predict strategy use and task performance and that value would predict future intentions. The structural models of the history and mathematics data offer some support for these proposed relations. Specifically, some of these relations were statistically significant and appear similar across domain.

For instance, students' competency beliefs significantly and similarly predicted the use of deep-processing strategies and achievement value significantly influenced students' future intentions in both history and mathematics. Additionally, competency beliefs and achievement values were significantly related, as indicated by the relation between their disturbances, in both domains. Further, history competency beliefs significantly predicted surface-level strategy use and task performance. These relations were not statistically significant for mathematics. However, the relation between mathematics competency beliefs and surface-level strategy use approached statistical significance and the history and mathematics confidence intervals overlapped. However, the degree to which the confidence intervals overlapped was very small (i.e., at the thousandths level). With respect to task performance, the relation between mathematics competency beliefs and task performance was weak and did not approach statistical significance, even though the confidence intervals overlapped. These findings offer some support for the relations between competency beliefs and strategy use as well as for the influence of value on future intentions. Additional work is needed to more fully understand the constructs that influence task performance.

There were also variations in the effects of reported strategy use across domains. That is, for mathematics, surface-level strategy use had a significant negative effect on students' task performance. This path was not statistically significant in the history model. However the history and mathematics confidence intervals overlapped, suggesting that the path values were somewhat similar. The direct effects from the reported strategy use variables to history task performance were not statistically significant, nor did they approach statistical significance.

In this investigation, the Lagrange Multiplier test was used to suggest additional paths that may be appropriate. Additions to the models based on this test varied across domain. Specifically, for the history data, beliefs about the isolation and certainty of knowledge were significantly related to students' intentions. These paths were not suggested for mathematics. Further, in the mathematics model, a path was added between competency beliefs and intentions but the Lagrange Multiplier test did not suggest this path for the history model. Given the post hoc addition of these paths, these differences between the models should be interpreted with caution. Before conclusions are drawn, these relations should be replicated with new data

Despite some differences between the models, the relations between the constructs tended to be similar across domains. That is, for those relations that were statistically significant, the direction and approximate strength were the same for history and mathematics. Further, in cases where a path was significant in one model and non-significant in the other model, the non-significant path often approached significance and the nature of the relation (i.e., positive or negative) was similar. These similarities offered support for the hypothesized model. However, additional work is needed to determine how and why relations differ across domains.

CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Summary and Conclusions

Based on a review of the epistemological and motivation literatures, I proposed a model of the relations between students' epistemological beliefs, motivation, and learning outcomes (see Figure 1). The current investigation was designed to test a portion of that model (see Figure 2). Assessing this model also offered the opportunity to replicate previous studies and contribute to the literatures in epistemological beliefs and motivation. For instance, this investigation addressed the domain-specific and multidimensional nature of epistemological beliefs. Additionally, this investigation explored expectancy-value constructs with a sample of college students. In this section, I summarize the results from Chapter IV and relate them to issues in the epistemological belief and motivation literatures.

Multidimensionality and Domain-Specificity of Epistemological Beliefs

Within the epistemological belief literature, the multidimensional view of knowledge beliefs is widely accepted (e.g., Hofer & Pintrich, 1997). Although there has been some debate as to what constitutes an epistemological belief, the core aspects of students' epistemological beliefs appear to be beliefs about the structure of knowledge, stability of knowledge, and source of knowledge. In addition to examining the dimensionality of students' epistemological beliefs, researchers have also begun to examine the domain-specificity of students' knowledge beliefs (e.g., Hofer, 2000).

However, because examinations of students' domain-specific epistemological beliefs are more recent, domain-specific belief measures are relatively new and have not been used in a large number of investigations. Further, individually, the existing domain-specific measures do not address the core aspects of students' epistemological beliefs adequately and the use of those measures has not been generalized to multiple domains. For instance, the DSBQ only included two aspects of epistemological beliefs (i.e., beliefs about the structure of knowledge and the nature of knowledge acquisition) relative to two domains (i.e., history and mathematics). On the DEFBQ, items designed to assess beliefs relative to the structure and stability of psychology and science knowledge loaded on the same factor suggesting that these belief dimensions may not be distinct.

In this investigation, I combined items from both measures to assess students' beliefs about the structure, stability, and source of history and mathematics knowledge. Specifically, items related to the structure of knowledge were taken from the DSBQ and items related to the stability and source of knowledge were taken from the DEFBQ. Further, items were modified to address students' beliefs about history and mathematics knowledge. This provided an opportunity to examine beliefs about the structure, stability, and source of knowledge in relation to one another and to replicate previous findings with the DEFBQ in two new domains (i.e., history and mathematics).

The results indicated that beliefs about the structure, stability, and source of knowledge as measured in this investigation were distinct aspects of students' belief systems and these beliefs were domain-specific in this investigation. However, the consistency in the types of beliefs that emerged across domains also provided evidence of underlying general epistemological beliefs. Consequently, this investigation supported the stance that epistemological beliefs are multidimensional and that elements of these beliefs are simultaneously domain-specific and domain-general. That is, this view of epistemological beliefs proposes that students' knowledge beliefs are multi-layered and multifaceted and that the emergence of different aspects of this complex belief system depends on the context of the situation (e.g., Buehl & Alexander, 2001).

The items from the DEFBQ appeared to generalize to domains other than those the measure was designed to assess. Thus, this investigation indicated that domain-specific measures can be modified to assess beliefs in various academic domains. However, the items from the DEFBQ also did not load clearly on a single factor, which further suggested that some of the items contained elements of more than one epistemological dimension.

These findings contribute to the literature on the nature of epistemological beliefs in two ways. First, the investigation offers support for the multidimensional and multilayered (i.e., domain-specific and domain general) approach to epistemological beliefs. Second, this investigation replicated previous findings with the DEFBQ with different domains, thereby contributing additional information about the validity and reliability of the items on the measure.

Expectancy-Value Theory in College Students

The Eccles and Wigfield (e.g., Eccles et al., 1983; Wigfield & Eccles, 2000) expectancy model is one approach to achievement motivation that has been explored extensively in school-age students. Specifically, their work has examined the nature of students' ability beliefs, expectancies for success, and achievement values in various domains. Prior research supported the domain-specificity of students' competency beliefs and values. While data from previous investigations evidenced differentiated intrinsic, importance, and utility value constructs, ability beliefs and expectancies did not appear to be distinct in school-age students. This lack of differentiation could be attributed to the developmental level of the sampled population, to measurement issues, or to the close association of the ability and expectancy constructs. Evidence indicated that aspects of value emerge as students progress through school (e.g., Wigfield et al., 1997). This may be true for ability and expectancy beliefs as well. Further, the importance of these constructs is underscored by previous findings that students' beliefs about their abilities and expectancies to do well predicted achievement, whereas achievement value predict the choices students make (Meece et al., 1990).

The current investigation extended this literature by examining the ability beliefs, expectancies for success, and achievement values of college students. The Eccles and Wigfield (Wigfield & Eccles, 2000) model appeared to be particularly relevant for this population given the emphasis placed on achievement and the various academic and career choices presented to college students. The measures used in this investigation assessed ability beliefs, expectancies for success, and achievement value at a domain-specific level. In addition to intrinsic value, importance value, and utility value, this investigation assessed the cost aspect of achievement value.

The results of this investigation replicated previous findings (e.g., Wigfield & Eccles, 1992). As expected, there was support for the domain-specificity of the constructs. With respect to ability beliefs and expectancies for success, evidence indicated that despite theoretical distinctions, there is considerable overlap in these constructs when they are assessed empirically in college students. That is, the empirical evidence did not support separate ability and expectancy factors. Based on this finding and prior research, it appears that this overlap is not due to the developmental level of the students but may be reflective of how the constructs are defined and assessed. Moreover, the distinctions between the different aspects of achievement value, including cost value, were supported in this investigation.

The findings with respect to students' expectancies and values contribute to the motivation literature in multiple ways. First, by sampling college students, the investigation offers a view of population that had been previously unexplored with respect to the Eccles et al. (1983) expectancy-value model. Second, in this investigation, the ability and expectancy beliefs did not differentiate empirically in the college sample, thereby disconfirming the hypothesis that the emergence of these constructs is related to the age of the participants. Third, items were developed to assess the cost value associated with tasks in different academic domains. These items can be used in the future to explore the construct of cost value, a previously unexplored aspect of value, in relation to other constructs. Fourth, this investigation replicated findings with respect to the emergence of intrinsic, importance, and utility value, providing support for the aspects of value proposed by Wigfield and Eccles (1992).

Relations between Epistemological Beliefs, Motivation, and Learning Outcomes

Within the educational literature, epistemological beliefs have been studied in relation to various cognitive aspects of students' learning and achievement (e.g., strategy use and academic performance; Hofer, 2000; Ryan, 1984). In recent decades, achievement motivation has also been studied in relation to academic achievement and other learning outcomes (Murphy & Alexander, 2000; Pajares, 1996). This body of work indicates that epistemological beliefs and achievement motivation are important components of the learning process. Further, there is evidence to suggest that epistemological beliefs may be related to students' achievement motivation (e.g., Paulsen & Feldman, 1999). However, despite the apparent connections, relatively few attempts have been made to integrate these bodies of research.

The current investigation attempted to bridge this gap in the literature. Based on a review of the literatures, I proposed a working model of the relations between students' epistemological beliefs, achievement motivation, and learning outcomes (see Figure 1). This model provided a theoretical basis for why the variables may be related and served as a guide for designing the empirical investigation. Consequently, it is important to examine the findings of this investigation in relation to the hypothesized model. I first address the direct paths in the model and then discuss the indirect paths.

<u>Direct paths: Epistemological beliefs.</u> The model predicted that students' epistemological beliefs would predict students' competency beliefs, achievement value, and strategy use. Because epistemological beliefs were scored such that higher numbers represented what is often thought of a more naïve epistemological position, students' beliefs about the isolation, certainty, and authority as the source of knowledge were hypothesized to be negatively related to students' competency beliefs, achievement values, and strategy use. In some instances, the data upheld these predictions and in others, it did not.

Specifically, beliefs about the isolation of knowledge and authority as the source of knowledge negatively predicted competency beliefs and achievement values, as expected. That is, more sophisticated beliefs with respect to the interrelatedness and the source of knowledge were associated with higher levels of motivation. In contrast, students' beliefs about the certainty of knowledge were positively related to their achievement motivation. That is, the more students believed knowledge was certain (i.e., a naïve belief), the more confidence they expressed in their competency and the more they valued achievement in the respective domain. Recognition of the uncertainty of knowledge (i.e., a sophisticated belief) was accompanied by lower levels of competency beliefs and achievement value. These findings indicate that how we define a sophisticated or naïve epistemological belief may vary by domain and the developmental level of the student.

The model also predicted that epistemological beliefs would exert a negative influence on students' strategy use. That is, I hypothesized that more naïve epistemological stances would predict less strategy use. This prediction was not upheld. Specifically, although stronger beliefs in the certainty of knowledge (i.e., a naïve belief) predicted low level of reported surface level strategy use, stronger beliefs in authority as the source of knowledge resulted in higher levels of strategy use. Further, these relations were only apparent for the history data.

These findings contribute to the current literature by demonstrating that epistemological beliefs and motivation are, indeed, related. However, because the nature of the relation between beliefs about the certainty of knowledge and motivation was in the opposite direction than hypothesized, perhaps the relation between epistemological beliefs and motivation is not as straightforward as initially hypothesized. This issue is addressed more fully later in the chapter.

<u>Direct paths: Competency beliefs.</u> The proposed model predicted that higher levels of competency beliefs would be associated with higher levels of strategy use and task performance (i.e., knowledge gain). The data from this investigation partially

supported the hypothesized relations. Specifically, in both domains higher levels of competency beliefs were associated with reported deep-processing strategy use. For the history data, competency beliefs were also related to higher levels of reported surface-level strategy use and task performance. However, these relations did not emerge for the mathematics data and competency beliefs were not significantly related to moderate level strategy use in either domain. Despite the nonsignificant relations between competency beliefs and reported strategy use, these findings contribute to the current motivation literature by offering support for the relation between students' beliefs about their abilities (i.e., competency beliefs) and their performance. This relation has been discussed and identified in previous investigations.

Direct paths: Achievement values. Based on previous research (e.g., Eccles et al., 1983; Meece et al., 1990), I predicted that achievement value would be related to students' future intentions. That is, the more students valued the task, the more they would want to engage in related learning activities in the future. This relation was supported by the data in both domains, thereby offering further support for the influence of achievement value on students' choices. Additionally, this investigation extends the current literature by offering support for the relation between achievement value and choices in college students.

Direct paths: Reported strategy use. Based on a large body of prior research, the proposed model predicted that reported strategy use would be directly related to students' task performance. Further, I predicted that higher levels of the different types of strategy use would be related to higher levels of performance on the learning task. These predictions were not supported by the data in this investigation. That is, there was only one significant relation between reported strategy use and performance and the nature of the relation was not in the anticipated direction. Specifically, for mathematics, students who reported higher levels of surface-level processing did not perform as well on the mathematics learning tasks as students who reported low levels of surface-level processing. Although this relation can be explain in that apparently more than surface-level processing was needed to learn the material, the other forms of strategy use were not significantly related to performance. Given prior research findings, these nonsignificant relations suggest that the strategy measures may not have been effective in assessing students' actual strategic processing. Additionally, data from the strategy measure had low reliability Consequently, despite the lack of statistically significant findings in this investigation, I intend to retain the path between strategy use and performance.

Indirect paths: Epistemological beliefs. The proposed model suggests that students' epistemological beliefs indirectly influence their strategy use, task performance, and future choices due to their relation to the motivation variables in the model. These indirect relations were supported in this investigation. Specifically, epistemological beliefs were related to competency beliefs, which in turn task performance. Additionally, epistemological beliefs were related to achievement values, which in turn influenced students' intentions to engage in future learning tasks.

Indirect paths: Competency beliefs. The proposed model also indicates that competency beliefs may be indirectly related to task performance via strategy use. The data did not support this indirect relation. As previously mentioned, the lack of a significant relation between competency beliefs and strategy use and/or strategy use and competency beliefs is likely to the low reliability of the strategy use measure. Again, given previous research, I would not change this path in the hypothesized model.

Summary. Overall, this investigation confirmed many of the proposed relations between students' epistemological beliefs, motivation, and learning outcomes. Further, the nonsignificant relations appear attributable to methodological limitations (e.g., the reliability and validity of the strategy measure). Collectively, the findings from this investigation contribute to the literature in three significant ways. First, this study offers a potential model of the relations among the constructs that can be used to guide future investigations. Given the significant relations that were identified, this model appears to be a plausible representation of the relations between the constructs. Future work can expand on these relations and develop the model more fully.

Second, the empirical results suggest specific avenues for future research. For instance, the various aspects of epistemological beliefs were differentially related to students' motivation. This suggests that the relations between epistemological beliefs and motivation may be more complex than initially hypothesized. Perhaps we need to reconceptualize what is viewed as a more appropriate epistemological stance and examine how epistemological beliefs may interact with other variables to influence students' motivation. Third, this investigation replicated previous findings with respect to the Eccles et al. (1983) expectancy-value model.

Limitations

This investigation addressed several of the gaps in the current epistemological belief and motivation literatures. However, it was also limited in certain respects. Some of these limitations were related to the design of the study and, thus, known a priori.

Others emerged during data analysis. I first address those limitations that were recognized a priori, and then discuss the limitations of which I became aware after data were collected and analyzed.

At the outset, I recognized that although a certain level of exposure to history and mathematics could be assumed, as a result of university admission standards, the participants would have varied backgrounds and experiences with respect to those two domains. Also, students may or may not have been currently enrolled in a mathematics or history course and their performance on the learning task was not associated with any personal consequences (e.g., a grade). Thus, the learning experience designed for this investigation may have seemed somewhat contrived. Should this be the case, it could be argued that this activity did not fully represent students' learning and behavior in a classroom context. Some of the constructs (e.g., value and future intentions) may behave differently or be more salient to students when they are in actual achievement settings.

Additionally, with respect to student choice, the current investigation did not assess the decisions that students actually make. Instead, I focused on students' self-report of activities they were likely to select if given the opportunity. Further, the model that I proposed (see Figure 1) suggests that epistemological beliefs exert a direct influence on students' motivation. However, all of the variables were assessed in the same session. Consequently, although structural equation modeling was employed to assess the proposed model, the directionality of the proposed relations could not be determined.

This investigation was also limited in that it did not address all of the constructs included in the proposed model. In particular, one group of constructs, Immediate

Responses (e.g., effort and persistence), was not assessed at all. As noted in Chapter 3, the exclusion of this aspect of the model may have inflated the relation between motivation (i.e., competency beliefs and achievement values) and learning outcomes (i.e., task performance and future intentions). Additionally, given the reciprocal relation between cognitive processes (i.e., strategy use) and immediate responses, the relation between strategy use and task performance may have appeared stronger than it would have if a measure of students' immediate response (e.g., persistence) had been included.

After collecting, analyzing, and reflecting on the data, several other limitations became apparent. For instance, the data from the strategy inventory had a relatively low level of reliability. This was not anticipated and may have impeded the emergence of significant relations. Also, due to the number of measures and the learning task, fatigue may have been a factor. That is, although the length of time students needed to complete the measures was judged as reasonable, the amount of mental processing students were required to perform may have been demanding. This determination was suggested by students' performance on the post-reading mathematics knowledge test, as well as the unanticipated findings with respect to hypothesized relations for mathematics.

Additionally, upon further reflection and consideration of the proposed model, I now hypothesize that the relation between epistemological beliefs and motivation may be more complex than what is depicted in the initial model. That is, the model presents a direct linear path from epistemological beliefs to motivation. This relation implies that more sophisticated epistemological beliefs will be related to higher levels of motivation and less sophisticated beliefs will be related to lower levels of motivation. However, given the complexity of students' epistemological beliefs and motivation, this now seems overly simplistic. Instead, students' motivation in specific academic domains may be the product of the interaction between students' beliefs about knowledge in that domain and their general perceived abilities and preferences. That is, students' domain-specific epistemological beliefs may interact with their beliefs about their ability to do specific types of tasks (e.g., problems that have a specific response or tasks that require one to recognize and forge connections between ideas and content areas) and their preference for these different types of tasks. The degree to which students' domain-specific epistemological beliefs align with their perceived abilities and preferences may then determine their level of motivation relative to different academic domains.

For instance, suppose two students, Ester and Evan, both believe that knowledge in history is well integrated with knowledge in other domains and that history knowledge is uncertain and changing. In addition to their beliefs about history knowledge, Ester believes that she is good at making connections between ideas and subject areas and she enjoys working on problems that do not have a clear-cut answer. In contrast, Evan believes that he is not good at making connections between different ideas and he prefers problems that have a definite right answer. I would predict that these students would have different levels of motivation related to history. Specifically, Ester would likely have higher levels of competency beliefs and task value whereas Evan would not be motivated in history. Additional work is needed to specify these relations and study them empirically.

Implications for Theory, Research, and Practice

Despite these limitations, the findings from the current investigation have implications educational theory, research, and practice. Given the basic and exploratory character of the study, however, the implications for practice must be judged as more speculative than those for theory and research.

Implications for Theory and Research

Conceptualization and Measurement of Constructs

The findings of this investigation indicate the need for additional measure development with respect to students' epistemological beliefs and their competency beliefs and expectancies for success.

Conceptualizing and measuring epistemological beliefs. In this investigation, elements from two epistemological belief measures (i.e., the DSBQ and DFEBQ) were combined and distinct domain-specific beliefs emerged as anticipated. Given these findings, researchers should consider the domain-specificity of beliefs in future investigations. Acknowledging and understanding the specificity of these beliefs has implications for the role they play in students' cognition as well as how they are assessed. That is, domain-specific epistemological beliefs may be much more powerful predictors of certain behaviors (e.g., conceptual change) than more general epistemological beliefs. Consequently, to understand the relations between epistemological beliefs and various learning processes and outcomes in specific academic domain, epistemological beliefs should be assessed at the domain level. General beliefs may be more relevant in studies of more general cognitive skills (e.g., deductive reasoning).

Despite the emergence of domain-specific beliefs, items from the measures did not cleanly assess the various aspects of epistemological beliefs. Specifically, items relative to the stability and source of knowledge loaded on the same factor. Additional work is needed to develop valid and reliable measures of epistemological beliefs that adequately assess the various aspects of individuals' belief systems. Further, given the domain-specificity of students' beliefs, such measures should be validated within various domains. More refined domain-specific epistemological belief measures would be an asset to researchers who wish to examine domain-specific epistemological beliefs in relation to other constructs.

Findings with respect to the Certainty of Knowledge belief factor also suggest that additional theoretical work should address how epistemological beliefs are conceptualized. That is, placing epistemological beliefs on a continuum and classifying them as naïve or sophisticated is not necessarily theoretically meaningful. Instead, researchers need to determine what types of epistemological beliefs are appropriate for students at different developmental levels and for different academic domains. Further, new conditionalized terminology to characterize where students' beliefs fall on the epistemological continuum may also benefit the field.

<u>Conceptualizing and measuring ability beliefs and expectancies for success</u>. The outcomes of the current investigation suggested the need for additional theoretical and empirical work with respect to the conceptualization and measurement of students' ability beliefs and expectancies for success. Specifically, despite theoretical distinctions, items related to ability beliefs and expectancies for success loaded on the same factor. This finding is consistent with previous findings suggesting that the apparent convergence of these constructs may be due to how they are conceptualized and measured. If this distinction is important for modeling students' epistemological beliefs and motivation, a means to tease these constructs apart should be developed.

Explorations of Achievement Values

Four aspects of achievement value were assessed in this investigation with a sample of college students. This was significant due to the age of the sampled population, as well inclusion of the cost value component. Based on the findings from this investigation, there are two avenues for future theory and research related to achievement value that merit consideration. First, the achievement values of college students should be discussed and studied in more depth. For instance, how do the different aspects of value influence the different types of choices college students encounter (e.g., study habits, course enrollment, and major selection)? A related issue pertains to understanding how college students negotiate the achievement values associated with competing tasks. Are certain aspects of value more salient than others and consequently given more weight? For example, how does a student decide between taking a writing course that has intrinsic value and taking a mathematics course that has a high level of utility value? Such issues need to be examined empirically.

Second, the development and emergence of the cost value for younger students aspect of achievement value warrants examination. Previous research implied that the intrinsic value, importance value, and utility value emerge over time (e.g., Wigfield & Eccles, 1992). It is not clear when cost value first emerges and becomes a salient factor to students. Cost value may be of particular importance at the high-school level who are presented with more choices with respect to school and extra curricular activities than younger students. They also are in the process of making decisions about high school course selection and, more importantly, college.

Modeling Epistemological Beliefs, Motivation and Learning Outcomes

The current investigation offered support for the proposed relations between epistemological beliefs, motivation, and learning outcomes. The significant findings between the constructs in this investigation have significant implications for future research. For one, the model needs additional testing and exploration. There are multiple ways to proceed with this endeavor.

First, the relations between the variables included in the current investigation could be replicated and examined more closely. For example, researchers could investigate the variables from the current investigation relative to different domains and types of tasks to ensure that the identified relations are generalizable. Further, the use of more reliable measures (e.g., strategy measure) and more authentic tasks may provide support for relations that were not identified in the current study. Additionally, it is important to tease apart the relations between epistemological beliefs, competency beliefs, and achievement values. That is, epistemological beliefs significantly influenced students' achievement values, but the various aspects of achievement motivation were not included in the assessed model. Our understanding of the relations between these constructs may be furthered by examining how the different dimensions of epistemology are related to the different aspects of achievement value. Additionally, as discussed in the Limitations section, the current view of the relation between epistemological beliefs and motivation may be overly simplistic. The model needs to be reconceptualized to reflect the possibility of intervening variables between epistemological beliefs and motivation and these relations should be explored empirically.

Second, future studies should address portions of the proposed model that were not included in the current investigation. That is, additional types of motivation (e.g., goal orientations), cognitive processes, and learning outcomes require examination in relation to the different dimensions of students' epistemological beliefs. Subsequent investigations could also include measures of students' affective responses and learning tactics.

Third, the relations proposed in the model need to be assessed in longitudinal investigations. That is, the current study assessed all of the variables in the same session. To adequately assess the causal relations proposed in the model, the variables should be assessed over time. There is a broad range of options with respect to conducting longitudinal investigations of the proposed model. For instance, a study could examine students' epistemological beliefs, motivation, and learning in relation to a specific task (e.g., performance on a test given at the end of a chapter or unit). These variables could also be assessed and charted over the course of an academic semester or year. In addition, a large-scale longitudinal investigation could be conducted in which students' beliefs, motivations, and learning outcomes are studied over a period of years. For example, students could be studied over the course of their high school or college careers to determine how their beliefs change as a result of different experiences and how these changes in their beliefs influence their motivation and learning.

The significant relations identified in this investigation also have important implication with respect to how epistemological beliefs are treated in research and practice. That is, the current investigation indicates that epistemological beliefs do not exist in isolation. Instead, they are related to students' motivation and subsequent learning. Thus, epistemological beliefs may offer educators an additional means to improve students' motivation and achievement. More specifically, teachers may be able to change students' motivation and performance by changing their epistemological beliefs. Additional studies are required to determine how to change students' beliefs to maximize students' learning and development as well as what kinds of beliefs teachers should attempt to foster. The persuasion and conceptual change literatures may be particularly relevant in addressing these issues.

Implications for Practice

The current investigation was designed to address theoretical issues related to students' epistemological beliefs, motivation, and learning outcomes. The primary implication this investigation has for practice is that epistemological beliefs are indeed important. To a busy teacher, students' beliefs about knowledge may appear to be a rather esoteric issue that has little bearing on her classroom and students' learning. However, this investigation indicated that epistemological beliefs are an important component of the learning process. Educators should be aware of these beliefs and their importance.

Moreover, this investigation demonstrated that epistemological beliefs deserve to be addressed in the classroom. That is, epistemological beliefs directly influenced motivation and reported strategy use and indirectly influence students' performance and future choices. Addressing students' epistemological beliefs in the classroom may help prepare students for learning and result in greater knowledge gains and higher test scores.

Additionally, one of the more interesting findings from this investigation was the determination that beliefs about the certainty of knowledge positively influenced students' motivation. This relation implies that when knowledge appears certain students feel more confident that they can master the information and that it is valuable to them. In contrast, if knowledge is viewed as uncertain and evolving students have lower levels of confidence and do not view the domain or task as valuable. Previously, I discussed how this unexpected finding may be attributable to the way epistemological beliefs are conceptualized. However, there may be an alterative reason for this finding.

Experts in various domains are likely to agree that knowledge is uncertain and evolving. Further, recognizing the tentative and contextual nature of knowledge could be viewed as one of the purposes of higher education (e.g., Perry, 1970). However, in educational practice, emphasis is often placed on the certainty of knowledge. For instance, students are regularly expected to learn specific sets of information and to provide a correct response at the appropriate time (e.g., a test). Consequently, how we teach and assess student learning suggests that knowledge is certain. Perhaps students would benefit by altering approaches to learning that emphasize the certainty of knowledge or by discussing the ways in which knowledge is and is not certain.

Closing

This investigation was designed to assess a model of the relations between students' domain-specific epistemological beliefs, motivation, and learning outcomes (i.e., task performance and future choices). Evidence supported various aspects of the model suggesting that epistemological beliefs, motivation and learning are related. However, this investigation is a single step in the journey to understand students' cognition and motivation. Additional work is needed to understand the nature of students' beliefs and the role they play in the learning process.

Appendix A

Table 1

Table 1

Measurement of Epistemological Beliefs

Author(s), Year	Data Source/ Measure	Type of Questions	Beliefs Assessed	Participants	Form of Analysis	Outcome	Level of Beliefs
			Unidimensional/Synchronous Approaches				
Perry's Scheme							
Perry, 1970	*Checklist of Educational Values* (CLEV)	Likert scale items	Students' preference for dualistic or relativistic thinking and their dependence on authority of individual judgment	Male college students	Factor analysis	33 items loaded on one factor (Adherence) representing the degree to which students believe in right/wrong knowledge	Academic and general knowledge beliefs
	Interview	Open-ended questions	Encouraged students to talk about meaningful experiences; discussed challenges encountered in academic work	Male college students	Read interview transcripts for emergent themes; Trained experts rated students' stage in the proposed scheme	Proposed a scheme of intellectual development with 9 stages; Scheme validated by high level of consistency in ratings	Academic and general knowledge beliefs
Moore, 1989	*Learning Environment Preferences*	Likert scale items	Related to 4 of Perry's 9 stages	College students	Factor analysis	Identified 4 factors related to 4 of Perry's 9 stages	Academic knowledge beliefs

Ryan, 1984	Perry's seven item dualism scale	Likert scale items	Seven items taken from Perry's Adherence scale	College and medical students	Reliability analysis	Students with mean scores (max score 5) of 3 or more classified as dualists, students with mean scores less than 3 classified as relativists	Academic and general knowledge beliefs
Women's Ways of Knowing							
Belenky, Clinchy, Goldberger, & Tarule, 1986	*Women's Ways of Knowing Interview*	Open-ended questions	Encouraged to discuss significant experiences, relationships, education, gender, and ways of knowing	Primarily college educated women; sample also included women seeking social services	Phenomeno-logical approach; examined responses for emergent themes	Proposed 5 perspectives women may adopt organized around the metaphor of voice	General knowledge beliefs
Buczynski, 1993	*Ways of Knowing Instrument*	Likert scale items	Addressed the perspectives proposed by Belenky et al.	College women	Exploratory factor analysis	Identified 5 factors representing 5 proposed perspectives	General and academic knowledge beliefs
Knight, Elfenbein, & Messina, 1995	*Knowing Styles Inventory*	Likert scale items	Assessed the Connected Knowing and Separate Knowing perspectives proposed by Belenky et al.	College students	Exploratory factor analysis	Identified 2 factors said to represent Connected Knowing and Separate Knowing	General knowledge beliefs

Galotti, Clinchy, Ainsworth, Lavin, & Mansfield, 1999	*Attitudes Toward Thinking and Learning Survey*	Likert scale items	Assessed the Connected Knowing and Separate Knowing perspectives proposed by Belenky et al.	College students	Principal components analysis	Identified 2 components said to represent Connected Knowing and Separate Knowing	General knowledge beliefs
Epistemological Reflection Model							
Baxter Magolda, 1992	Annual interviews	Open-ended questions	Encouraged students to talk about "their role as learners, the roles of peers and instructors, their perception of evaluations of their work, the nature of knowledge, and educational decision making." (Baxter Magolda, 2002)	College students	Grounded theory approach; transcribed interviews divided into units, units sorted into categories to allow themes to emerge	Proposed the Epistemological Reflection Model consisting of four different ways of knowing	Academic knowledge beliefs
	Measure of Epistemological Reflection (MER)	Open-ended questions	Addressed topics covered by the interview	College students	Standardized rating protocol	Not used often due to difficulties in interpreting responses; interview methodology preferred	Academic knowledge beliefs

Reflective Judgment Model							
King & Kitchener, 1994	*Reflective Judgment Interview* (RJI)	Semi-structured interview	Presented individuals with four ill-structured tasks and asked questions designed to assess their beliefs about knowledge and their justification for those beliefs	High school, college, and graduate students, and non-student adults	Examined transcripts for patterns; trained raters used the Reflective Judgment Scoring Rules to evaluate and classify individuals' responses	Proposed the Reflective Judgment Model, a 7 stage model	General knowledge beliefs
Wood & Lynch, 1998	*Reflective Judgment Essay*					Problems obtaining ratable data	General knowledge beliefs
Kuhn's Epistemological Understandings							
Kuhn, 1991	Interviews	Semi-structured interviews	Presented individuals with three social problems and asked them to explain the cause of the problem, explain how they came to hold that position, and provide supporting evidence	Cross section of individuals in their teens, 20s, 40s, and 60s	Coding protocol	Identified three levels of epistemological understanding	General knowledge beliefs

Kuhn, Cheney, Weinstock, 2000	*Epistemological Understanding by Judgment Domain*	Closed-response questions	Three items per judgment domain (i.e., personal taste, aesthetic, value, social truths, physical truths)	2nd, 3rd, 5th, 8th, 12th grade students, college students, and adults with varying levels of education	Responses to questions determined classification as absolutist, multiplist, or evaluativist; Looked for consistency within each domain	Examined patterns across judgment domains	General knowledge beliefs; Domain specific (judgment domains)
Measures from Science Education							
Songer & Linn, 1991	*Views of Science Evaluation*	Short-answer and true false items	Assessed students' beliefs about the nature of science and scientific knowledge, about the work of scientists, and about what it means to learn science	Middle school students	Formed groups based on students' responses	3 beliefs groups	Academic knowledge beliefs; Domain-specific (science)
Roth & Roychou-dury, 1994	*Nature of Scientific Knowledge Questions*	Binary items (agree/ disagree) with justification	Addressed aspects of the nature of scientific knowledge and the nature of its origin from either an objectionist or constructivist position	High school students	Examined frequency agree vs. disagree response; Content analysis of justifications	Classified responses as objectivist, constructivist-relativist, or intermediate	Academic knowledge beliefs; Domain-specific (science)

Tsai, 1998a	Questionnaire adapted from Pomeroy (1993)	Likert scale items	Assessed students; views of science ranging from empiricist to constructivist views	Female middle school students in Taiwan	Created composite	Score representing degree to which students to endorse empiricist or constructivist views of science	Academic knowledge beliefs; Domain-specific (science)
Additional Measures							
Boyes & Chandler, 1992	*Epistemic Doubt Interview*	Semi-structured interview	presented two vignettes with probes intended to clarify how students constructed and planned to resolved competing knowledge claims	High school students	Trained raters classified responses	Responses classified as one of 4 epistemic orientations	General knowledge beliefs
Jacobson & Spiro, 1995	*Epistemic Beliefs and Preferences* (EBP)	Likert scale items	Designed to assess beliefs concerning the nature of learning and the organization of knowledge	College students	Reliability analysis	Participants with scores above the mean classified as having "complex" beliefs, participants with scores below the mean classified as having "simple" beliefs	General and academic knowledge beliefs

Multdimensional/Asynchronous Approaches							
Schommer-Aikins's Epistemological Belief Model							
Schommer, 1990	*Schommer Epistemological* Questionnaire (SEQ)	Likert scale items	Designed to assess 5 belief dimensions (i.e., structure of knowledge, source of knowledge, stability of knowledge, speed of learning, ability to learn)	College students	Exploratory factor analysis;	Identified 4 belief factors	General and academic knowledge beliefs
Jehng, Johnson, & Anderson, 1993	*Jehng's Epistemological Questionnaire* (JEQ)	Likert scale items	Designed to assess dimensions related to the certainty of knowledge, linearity of the learning process, source of authority, ability to learn, and speed of learning	College students	Confirmatory factor analysis	Identified 5 factors	General and academic knowledge beliefs
Schraw Dunkle, & Bendixen, 1995	*Epistemic Belief Inventory* (EBI)	Likert scale items	Designed to assess the five belief dimensions proposed by Schommer	College students and graduate students	Exploratory factor analysis	Identified 5 belief factors	General and academic knowledge beliefs
Youn, 2000	JEQ	Likert scale items	Replication study with the JEQ	Korean and American college students	Exploratory and confirmatory factor analysis	Identified 2 belief factors	General and academic knowledge beliefs

Chan & Elliot, 2002	Questionnaire	Likert scale items	Significantly modified the SEQ in an attempt to assess the same belief dimensions	Hong Kong teacher education students	Exploratory and confirmatory factor analysis	Identified 4 belief factors	General and academic knowledge beliefs
Buehl, Alexander, & Murphy, 2002	*Domain-Specific Belief Questionnaire* (DSBQ)	Likert scale items	Designed to assess students' beliefs about mathematics and history knowledge	College students	Exploratory and confirmatory factor analysis	Identified 4 belief factors, two within each domain	Academic knowledge beliefs; Domain-specific (mathematics and history)
Measures from Science Education							
Carey, Evans, Honda, Jay, & Unger, 1989	*Nature of Science Interview*	Semi-structured interview	Probedstudent conceptions of the goals of science, the nature of science questions, the purpose of experiments, the role of ideas in scientists' work, the nature of the processes by which science ideas change.	Middle school students	Responses for each section coded into categories reflecting three levels of understanding	Inferred 3 different levels of science understanding	Academic knowledge beliefs; Domain-specific (science)

Elder, 2002	Questionnaire	Open-ended written questions; Likert scale items	Open-ended questions addressed students' definition of science and their understanding of the sources of their own and scientists ideas for doing science Likert scale items addressed changing nature of science, role of experiments, coherence of science knowledge, and source of scientific knowledge	5th grade students	Responses to examined for emergent themes; Items grouped conceptually into 4 scales; examined reliabilities and made modifications; used multidimensional scaling to confirm scales	Classified definitions of science as poor, fair, or good; classified responses with respect to the source of knowledge along two dimensions (active vs. passive agent and independent vs. dependent endeavor) Identified 3 belief scales	Academic knowledge beliefs; Domain-specific (science)
Additional Measures							
Stodolsky, Salk, & Glaessner, 1991	Interview	Open-ended questions	Questions addressed students' perceptions of knowledge and learning in mathematics and social studies	5th grade students	Content analysis	Students have different perceptions of mathematics and social studies	Academic knowledge beliefs; Domain-specific (mathematics and social studies)

Hofer, 2000	*Discipline-Focused Epistemological Beliefs Questionnaire* (DEFBQ)	Likert scale items	Designed to assess students' discipline-specific beliefs with regard to the certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowing; science and psychology used as target domains	College students	Exploratory factor analysis	Identified 4 beliefs factors for each domain	Academic knowledge beliefs; Domain-specific (science and psychology)

Appendix B

Table 2

Table 2

Multidimensional Epistemological Beliefs Factors

Author(s)	Participants	Measure	Type of Analysis	Factors	Description of Factors	Sample Items
Schommer, 1990	College Students: 117 junior college students; 149 university students; 95% freshman and sophomores; 54% female	*Schommer Epistemological Questionnaire* (SEQ): 63 items organized into 12 subsets; designed to assess five belief dimensions; 5-point Likert scale	Exploratory Factor Analysis: 12 item subsets analyzed using principal factoring with varimax rotation	Simple Knowledge	"Knowledge is simple rather than complex"	When I study I look for specific facts.
				Certain Knowledge	"Knowledge is certain rather than tentative"	Scientists can ultimately get to the truth
				Innate Ability	"Ability to learn is innate rather than acquired"	The really smart students don't have to work hard to do well in school
				Quick Learning	"Learning is quick or not at all"	Successful students learn things quickly
Schommer, 1993b	High School Students: 405 freshman (56% female), 312 sophomores (54% female), 274 juniors (54% female), 191 seniors (53% female)	SEQ	Exploratory Factor Analysis: 12 item subsets analyzed using principal factoring with varimax rotation	Simple Knowledge	See Schommer, 1990	
				Certain Knowledge	See Schommer, 1990	
			Confirmatory Factor Analysis: Footnote mentions that CFA identified a four-factor solution; No statistics were reported.	Fixed Ability	Retitled but similar to Innate Ability in Schommer, 1990	
				Quick Learning	See Schommer, 1990	

Jehng, Johnson, & Anderson, 1993	College and Graduate Students: 54 freshman, 67 sopho-mores, 82 juniors, 100 seniors, 95 graduate students; 123 engineering students, 78 arts and humanities, 115 social sciences, 82 business students; 63% female	*Jehng's Epistemological Questionnaire* (JEQ): Modified that SEQ by replacing the Simple Knowledge dimension with items related to the linearity of the learning process (Orderly Processes); 51 items; 7-point Likert scale	Confirmatory Factor Analysis: LISREL used to assess a five factor model from 34 items (several items were eliminated before the CFA due to low inter-item correlations)	Certainty of Knowledge	See Schommer, 1990	
				Omniscient Authority	"Knowledge is handed down by teachers and other experts rather than formed by independent reasoning"	How much a person gets out of school mostly depends on the quality of the teacher.
				Orderly Processes	"The learning process tends to be regular rather than irregular"	Tests and exams can pretty much tell how well you are doing in a class
				Innate Ability	See Schommer, 1990	
				Quick Learning	See Schommer, 1990	
Schraw, Dunkle, & Bendixen, 1995	College and Graduate Students: 212 undergraduates (57% female) in Study I used to determine the structure of the belief inventory;	*Epistemic Belief Inventory* (EBI): 32 item measure designed to assess the 5 dimensions described by Schommer (1990); 5-point Likert scale	Exploratory Factor Analysis: Analyzed the 32 items with principal axis factoring; oblique and varimax rotations conducted; report results from varimax rotation	Fixed Ability	See Schommer 1990	
				Certain Knowledge	See Schommer, 1990	
				Omniscient Authority	See Jehng et al., 1993	
				Simple Knowledge	See Schommer 1990	
				Quick Learning	See Schommer 1990	

Qian & Alvermann, 1995	High School Students: 212 9th-12th grade students from 13 science classes; 47% female	SEQ	Exploratory Factor Analysis: 53 items (Omniscient Authority items not administered) submitted to a principal axis factor analysis with varimax rotation; 32 items retained	Quick Learning	See Schommer, 1990	
				Simple-Certain Knowledge	"Knowledge is simple and certain;" See Schommer, 1990	
				Innate Ability	See Schommer, 1990	
Kardash & Scholes, 1996	98 undergraduates	Short version of SEQ: 42 items related to the structure and certainty of knowledge and speed of learning; 11 of 12 SEQ subsets represented	Exploratory Factor Analysis: Principal-axis factor analysis of the 11 subset scores with varimax rotation	Quick Learning	See Schommer 1990	
				Certain Knowledge	See Schommer 1990	
				Innate Ability	See Schommer, 1990	
				Depend of authority	Authority as the source of knowledge	
Mori, 1999	College Students: 187 students enrolled in a Japanese course; 47% female	Short version of the SEQ: 40 items intended to assess 5 belief dimensions; 6-point Likert scale	Exploratory Factor Analysis:40 items submitted analyzed using the principal factor method with oblique and varimax rotation; oblique rotation used to interpret factors	Quick Learning	See Schommer, 1990	
				Simple Knowledge	See Schommer, 1990	
				Dependence on Authority	Related to the source of knowledge	You can believe almost anything you read
				Attainability of Truth	Relates to the "attainability of knowledge"	Scientists can get to the truth if they just keep searching for it.
				Innate Ability	See Schommer, 1990	

Cole, Goetz, & Willson, 2000	101 under-prepared college freshman	JEQ	Confirmatory Factor Analysis: Examined the conceptual structure underlying the subscales identified by Jehng et al. (1993)	Nature of Learning	Included Quick Process, Innate Ability, and Omnicient Authority subscales	
				Nature of Knowledge	Included Certain Knowledge and Rigid Learning subscales	
Hofer, 2000	College Students: 326 fist year college students; 53% female	*Discipline-Focused Epistemological Beliefs Questionnaire* (DEBQ): Designed to assess the four belief dimensions posited by Hofer & Pintrich (1997); each item refers to a specific field of study as a frame of reference; 27 items; 5-point Likert scale; Administered separately for psychology and science	Exploratory Factor Analyses: Conducted analyses separately for each discipline (i.e., psychology and science); items submitted to maximum likelihood procedures with varimax rotation	Certain/ Simple Knowledge	Similar to factor identified by Qian & Alvermann, 1995	Principles in this field are unchanging.
				Justification for Knowing: Personal	"Knowing is justified by individual opinion or first hand experience"	I am more likely to accept ideas of someone with first hand experience than the ideas of researchers in the field
				Source of Knowledge: Authority	"Relates…to expert knowledge, texts, and other external authority as the source of knowledge"	I am most confident that I know something when I know what the experts think
				Attainability of Truth	Truth is attainable	Experts in this field can ultimately get to the truth

Kardash & Howell, 2000	288 college students	SEQ	Exploratory Factor Analysis: Principal axis factor analysis of items subsets with varimax rotation	Nature of Learning	" the process of learning is clear-cut and unambiguous, stable and fixed, and based on passive acceptance of knowledge handed down by authority figures"
				Speed of Learning	See Schommer (1990)
				Certain Knowledge	See Schommer (1990)
				Avoid Integration	" learning consists of memorizing facts and keeping those facts separate and isolated"
Schommer-Aikins, Mau, Brookhart, & Hutter, 2000	Middle School Students: 1,269 7th and 8th grade students (52% female)	Epistemological Belief Questionnaire: 30-item developed from prior findings with SEQ and a pilot study with middle school students; 5-point Likert scale	Confirmatory Factor Analysis: Split the data in half to assess the hypothesized four-factor model using CFA in AMOS; Poor fit for the 4-factor model; 3-factor model fit the data well	Speed of Learning	See Quick Learning factor in Schommer (1990)
				Ability to Learn	See Innate Ability factor in Schommer (1990)
				Stability of Knowledge	See Certain Knowledge factor in Schommer (1990)

Youn, 2000	496 undergraduate and graduate students from the United States and 487 undergraduate and graduate students from South Korea	JEQ	Confirmatory Factor Analysis: multi-collinearity and multivariate kurtosis in both samples	US sample: Knowledge	Consisted of items from the Certainty of Knowledge, Orderly Processes, and Omniscient Authority factors
			Exploratory Factor Analysis: Principals axis method identified two factors in both samples	Learning	Consisted of items from Innate Ability and Quick Learning factors
			Confirmatory Factor Analysis: Used to examined the fit of a two-factor model in comparison to a five-factor model	Korean sample: Knowledge	Consisted of items from the Certainty of Knowledge and Orderly Processes factors
				Learning	Consisted of items from Innate Ability, Quick Learning, and Omniscient Authority factors
Clareabout & Elen, 2001	124 students; student population not specified--assumed to be high school students	SEQ	Exploratory factor analysis of items; 4 factors different from those identified by Schommer emerged; factor analysis with he four factors resulted in two factors	Truth for Scientist	Scientists are able to uncover the truth
				Effort Pays	Necessity of effort to learning

Youn, Yang, & Choi, 2001	Korean High School Students: 455 10th, 11th, and 12th grade students	JEQ (translated into Korean)	Exploratory Factor Analysis with varimax rotation	Knowledge	Items from Certainty of Knowledge, Omniscient Authority, and Orderly Processes factors	
				Learning	Items from Innate Ability and Quick Learning factors	
Buehl, Alexander, & Murphy, 2002	College Students: 181 undergraduates (72% female) in the EFA; 633 undergraduates (63% female) in the initial CFA; 523 undergraduates (73% female) in the second CFA	*Domain-Specific Belief Questionnaire* (DSBQ): measure developed to assess domain-specific epistemological beliefs; initial items based on the SEQ; items identical for two domains, mathematics and history; 10-point Likert scale	Exploratory Factor Analysis: 44 items submitted to principal axis factoring with oblimin rotation; two domain-specific factors emerged with evidence of additional factors Confirmatory Factor Analysis: revised items given to a new sample; four-factor domain-specific model; structure confirmed with a third data set	Integration of Knowledge in Mathematics	Beliefs about the interrelatedness of knowledge and problem solving in mathematics	It is important for students to integrate ideas in math with what they already know.
				Need for Effort in Mathematics	Beliefs about the amount to effort required to acquire new mathematics knowledge	Even if it takes a long time to learn a math concept, it is best to keep trying.
				Integration of Knowledge in History	Beliefs about the interrelatedness of knowledge and problem solving in history	History relates to data to data life.
				Need for Effort in History	Beliefs about the amount to effort required to acquire new history knowledge	Students who are good at history have to work hard.

Chan & Elliot, 2002	Teacher Education Students: 385 students from the Hong Kong Institute of Education (68% female); students in either a Chinese or English stream of study	Epistemological Belief Instrument; Translated the SEQ into Chinese; when the previous factor structure did not emerge for this sample, the authors added items and eliminated those that did not work well	Exploratory Factor Analysis: Principal axis factor analysis with varimax and oblimim conducted on the 12 subscales; original factor structure not replicated; subscales had low to moderate reliability; principal axis factor analysis conducted with the 63 item; the 12 subsets hypothesized by Schommer did not emerge; several steps taken to develop and revise items that assessed Schommer's proposed dimensions; redesigned items submitted to principal axis factor analysis with oblimin rotation Confirmatory Factor Analysis: LISREL8 used to model 30 items, loading on 4 factors; model fit the data well; factors reliable	Fixed/Innate Ability	"ability is…inborn and fixed at one end and one's ability is not innate and changeable at the other"	Our abilities to learn are fixed at birth.
				Authority/ Expert Knowledge	" source of knowledge is handed down by experts and authority…to knowledge being derived from one's personal experience and judgment"	I often wonder how much experts really know.
				Certainty Knowledge	"knowledge is certain unambiguous, and unchanged to a belief that knowledge is tentative and everchanging"	Scientific knowledge is certain and does not change.
				Learning/ Effort Process	"knowledge acquisition requires effort and…learning processes are more important than acquired facts…[to] learning needs little effort and acquired facts are more important at the other end	Learning something really well takes a long time and much effort.

Elder, 2002	211 5th grade students	Written Questionnaire: Open-ended questions addressed students' definition of science and their understanding of the sources of their own and scientists ideas for doing science; Likert scale items addressed changing nature of science, role of experiments, coherence of science knowledge, and source of scientific knowledge	Classification of open-ended responses along 3 dimensions (understanding of science, role of agent, and type of endeavor) Reliability and Multidimensional Scaling	Changing Nature of Science Role of Experiments and Source of Knowledge Source of Knowledge	"Knowledge in science changes and develops over time" "Scientific knowledge derives from testing and experimenting and from reasoning and thinking" "Scientific knowledge comes from authority figures, including teachers and books"	Scientific beliefs change over time Part of doing science is asking questions about other people's ideas Whatever the teacher says in science class is true

Wood & Kardash, 2002	793 under-graduates, medical, and graduate students	80-item questionnaire comprised of 58 items from SEQ and 22 items from JEQ	Exploratory Factor Analysis: Principal axis factoring of items with varimax, oblimin, quartimax, and promax rotation	Speed of Knowledge Acquisition	"learning is a quick…fairly straightforward process," to "learning is a complex, gradual process requiring both time and effort"	If something can be learned, it will be learned immediately.
				Structure of Knowledge	"knowledge is composed of discrete, unambiguous pieces to information," to "knowledge is often complex, interrelated, and ambiguous, with… no 'one right answer'"	I like information to be presented in a straightforward fashion; I don't like having to read between the lines.
				Knowledge Construction and Modification	"knowledge is constantly evolving, is actively and personally constructed, and should be subjected to questioning" to " knowledge is certain, passively received, and accepted at face value"	Wisdom is not knowing the answers, but knowing how to find the answers.
				Characteris-tics of Successful Students	"successful students 'are born that way'" to "successful students are characterized by their recognition that learning takes time and effort"	Successful students understand things quickly.
				Attainability of Truth	there is an "objective truth that can be known if scientists try hard enough to find it" to "rejection to the notions of objective truth and 'single right answers'"	Scientists can ultimately get to the truth.

Appendix C

Epistemological Belief Measure

Study ID # ___________________

Beliefs about Mathematics and History Knowledge **Directions:** Rate the following items by circling the appropriate number. Respond to each item based on what you believe. There are no right or wrong answers.	Strongly Disagree — Strongly Agree
1. Correct answers in history are more a matter of opinion than fact.	0----1----2----3----4----5----6----7----8----9
2. All mathematics experts understand the field the same way.	0----1----2----3----4----5----6----7----8----9
3. First-hand experience is the best way of knowing something in history.	0----1----2----3----4----5----6----7----8----9
4. If my personal experience conflicts with ideas in the mathematics textbook, the book is probably right.	0----1----2----3----4----5----6----7----8----9
5. First-hand experience is the best way of knowing something mathematics.	0----1----2----3----4----5----6----7----8----9
6. Mathematics is unrelated to day-to-day life.	0----1----2----3----4----5----6----7----8----9
7. In history, it is good to question the ideas presented.	0----1----2----3----4----5----6----7----8----9
8. I am more likely to accept the ideas of someone with firsthand experience then the ideas of history researchers.	0----1----2----3----4----5----6----7----8----9
9. Correct answers in mathematics are more a matter of opinion than fact.	0----1----2----3----4----5----6----7----8----9
10. All mathematics professors would probably come up with the same answers to questions in this field.	0----1----2----3----4----5----6----7----8----9
11. In history, most work has only one right answer.	0----1----2----3----4----5----6----7----8----9
12. Answers to questions in history change as experts gather more information.	0----1----2----3----4----5----6----7----8----9
13. I am most confident that I know something in history when I know what the experts think.	0----1----2----3----4----5----6----7----8----9
14. In mathematics, it is good to question the ideas presented.	0----1----2----3----4----5----6----7----8----9

Study ID # ___________________

	Strongly Disagree — Strongly Agree
15. Principles in history are unchanging.	0----1----2----3----4----5----6----7----8----9
16. If you read something in a history textbook, you can be sure it's true.	0----1----2----3----4----5----6----7----8----9
17. Most of what is true in history is already known.	0----1----2----3----4----5----6----7----8----9
18. Information learned in mathematics is useful outside of school.	0----1----2----3----4----5----6----7----8----9
19. Truth is unchanging in history.	0----1----2----3----4----5----6----7----8----9
20. Truth is unchanging in mathematics.	0----1----2----3----4----5----6----7----8----9
21. All history professors would probably come up with the same answers to questions in this field.	0----1----2----3----4----5----6----7----8----9
22. There are links between mathematics and other disciplines.	0----1----2----3----4----5----6----7----8----9
23. Sometimes you just have to accept answers from the mathematics experts, even if you don't understand them.	0----1----2----3----4----5----6----7----8----9
24. I am most confident that I know something in mathematics when I know what the experts think.	0----1----2----3----4----5----6----7----8----9
25. All history experts understand the field the same way.	0----1----2----3----4----5----6----7----8----9
26. There is no way to determine whether someone has the right answer in mathematics.	0----1----2----3----4----5----6----7----8----9
27. History relates to day-to-day life.	0----1----2----3----4----5----6----7----8----9
28. If you read something in a mathematics textbook, you can be sure it's true.	0----1----2----3----4----5----6----7----8----9
29. It is important for students to integrate new ideas in history with what they already know.	0----1----2----3----4----5----6----7----8----9
30. There is no way to determine whether someone has the right answer in history.	0----1----2----3----4----5----6----7----8----9
31. In mathematics, most work has only one right answer.	0----1----2----3----4----5----6----7----8----9

Study ID # ___________________

	Strongly Disagree — Strongly Agree
32. I am more likely to accept the ideas of someone with firsthand experience then the ideas of mathematics researchers.	0----1----2----3----4----5----6----7----8----9
33. There are links between history and other disciplines.	0----1----2----3----4----5----6----7----8----9
34. The information learned in history is useless outside of school.	0----1----2----3----4----5----6----7----8----9
35. Most of what is true in mathematics is already known.	0----1----2----3----4----5----6----7----8----9
36. It is important for students to integrate new ideas in math with what they already know.	0----1----2----3----4----5----6----7----8----9
37. Sometimes you just have to accept answers from the history experts, even if you don't understand them.	0----1----2----3----4----5----6----7----8----9
38. Principles in mathematics are unchanging.	0----1----2----3----4----5----6----7----8----9
39. Answers to questions in mathematics change as experts gather more information.	0----1----2----3----4----5----6----7----8----9
40. If my personal experience conflicts with ideas in the history textbook, the book is probably right.	0----1----2----3----4----5----6----7----8----9

Appendix D

Ability, Expectancy for Success, and Achievement Value Measure

Study ID # ___________________

Values and Expectancies about Mathematics and History **Directions:** Respond to the following items by circling the appropriate number.	
1. How important is it to you to understand mathematical content?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Important ... Very Important
2. In comparison to your other academic studies, how good are you in history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Much Worse ... Much Better
3. How worthwhile is the effort required to learn something in history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Worth It ... Very Worthwhile
4. How much do you like history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not Very Much ... Very Much
5. How successful would you be in a mathematics-related career?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not Very Successful ... Very Successful
6. Compared to other undergraduates in your major, how well would you expect to do on a college history test?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Much Worse Than Other Students ... Much Better Than Other Students
7. The time I would spend learning new history content is…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 A Waste Of Time ... Very Worthwhile
8. In general, how useful is what you learned in mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Useful ... Very Useful
9. In comparison to other undergraduates in your major, how good are you at mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Much Worse Than Other Students ... Much Better Than Other Students
10. You will be asked to read a passage related to history and respond to some questions based on what you will read. How well do you expect to do on the test?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Well ... Very Well
11. In comparison to your other academic studies, how good are you in mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Much Worse ... Much Better

Study ID # ___________________

Directions: Respond to the following items by circling the appropriate number.	
12. To me, being good at solving problems that involve mathematics or mathematical reasoning is…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Important ... Very Important
13. I find working on number puzzles and games…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Very Boring ... Very Interesting
14. How would you describe your mathematics ability?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Good ... Very Good
15. How important is it to you to do well in a college history course?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Important ... Very Important
16. How worthwhile is the effort required to learn something in mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 A Waste Of Time ... Very Worthwhile
17. How good would you be at learning something new in mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Good ... Very Good
18. In comparison to other undergraduates in your major, how good are you at history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Much Worse Than Other Students ... Much Better Than Other Students
19. How much do you like mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not Very Much ... Very Much
20. How successful would you be in a history-related career?r?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not Very Successful ... Very Successful
21. Compared to your other academic studies, how useful is what you learned in mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not Very Useful ... A Lot More Useful
22. The time I would spend learning new mathematics content is…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 A Waste Of Time ... Very Worthwhile
23. I find working on history tasks or questions…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Very Boring ... Very Interesting
24. Compared to your other academic studies, how important is it for you to be good at mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not As Important ... A Lot More Important
25. Compared to my other academic studies, mathematics is…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Very Boring ... Very Interesting

Study ID # ___________________

Directions: Respond to the following items by circling the appropriate number.	
26. How good would you be at learning something new in history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Good … Very Good
27. How useful is the history content you learned in school for performance in your other courses?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Useful … Very Useful
28. How good are you at history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Good … Very Good
29. How useful is the mathematical content you learned in school for performance in your other courses?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Useful … Very Useful
30. Compared to my other academic studies, history is…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Very Boring … Very Interesting
31. Compared to your other academic studies, how important is it for you to be good at history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not As Important … A Lot More Important
32. How useful is the history content you learned in school for your future career?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Useful … Very Useful
33. Compared to my other academic studies, the time spent learning mathematics is…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 A Waste Of Time … Very Worthwhile
34. Compared to other undergraduates in your major, how well would you expect to do on a college mathematics test?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Much Worse … Much Better
35. How important is it to you to understand historical content?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Important … Very Important
36. How worthwhile is the time spent reading an article or a book about history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 A Waste Of Time … Very Worthwhile
37. Compared to your other academic studies, how useful is what you learned in history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not As Useful … A Lot More Useful
38. I find working on mathematics tasks or problems…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Very Boring … Very Interesting
39. How important is it to you to do well in a college mathematics course?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Important … Very Important

Study ID # ___________________

Directions: Respond to the following items by circling the appropriate number.	
40. Compared to my other academic studies, the time spent learning history is…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 A Waste Of Time ... Very Worthwhile
41. How would you describe your ability in history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Good ... Very Good
42. In general, how useful is what you learned in history?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Useful ... Very Useful
43. To me, being good at problems that involve historical thinking is…	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Important ... Very Important
44. You will be asked to read a passage related to mathematics and respond to some questions based on what you will read. How well do you expect to do on the test?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Well ... Very Well
45. How useful is the mathematical content you learned in school for your future career?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Useful ... Very Useful
46. How good are you at mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Not At All Good ... Very Good
47. I find working on games and puzzles that relate to history...	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 Very Boring ... Very Interesting
48. How worthwhile is the time spent reading an article or a book about mathematics?	0-----1-----2-----3-----4-----5-----6-----7-----8-----9 A Waste Of Time ... Very Worthwhile

Appendix E

Two-Part Text

Statistics in Psychology: Regression

Galton and the Origins of Regression

Students and researchers in the social sciences often use statistics as a means to reduce large amounts of data to meaningful summary values.[1] That is, statistics help researchers understand and interpret various phenomena (e.g., school achievement). However, it is important to realize that the field of statistics was shaped by the ideas and perspectives of its founders.[2] Consequently, understanding the origins of various statistical techniques may aid students in understanding how and why such techniques are used. Here we discuss the statistical technique of regression. First, we discuss factors that influenced the development of the procedure. Second, we consider a typical use of regression.

In statistics, the term *regression* refers to *prediction*.[3] Specifically, regression procedures can be used to predict one set of measurements (e.g., college grades) based on another set (e.g., SAT scores). However, the term regression is often a point of confusion to students unfamiliar with its history. As Yule and Kendall noted

> The term “regression” is not a particularly happy one from the etymological point of view, but it is so firmly embedded in statistical literature that we make no attempt to replace it by an expression which would more suitably express its essential properties.[4]

The word *regression,* as Yule and Kendall suggested, is now part of the statistical lexicon and serves as a reminder of an important episode in the history of the discipline.

Sir Francis Galton (1822-1911) developed the basic concept of regression. During his lifetime, Galton made significant contributions to diverse fields including geography, meteorology, biology, statistics, psychology, and criminology and, for his many accomplishments, Galton was knighted in 1909.[5] However, it was Galton’s interest in heredity and scientific naturalism that most contributed to his conceptualization of regression.[6]

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[1] Bartz, A.E. (1999). *Basic Statistical Concepts.* (4th ed). Columbus, OH: Merrill.
[2] Cowles, M. (1989). *Statistics in Psychology: An Historical Perspective.* Hillsdale, NJ: Lawrence Erlbaum Associates.
[3] Minium, E. W., King, B. M., & Bear, G. (1993). *Statistical Reasoning in Psychology and Education.* (3rd ed). New York: John Wiley & Sons, Inc.
[4] Yule, G.U., & Kendall, M. G. (1950). *An introduction to the theory of statistics.* (14th ed). London: Charles Griffin, p 213..
[5] Gale Group (2001). *Gale Encyclopedia of Psychology*, 2nd ed. < http://www.findarticles.com/cf_dls/g2699/0001/2699000146/p1>
[6] Cowles, M. (1989). *Statistics in Psychology: An Historical Perspective.* Hillsdale, NJ: Lawrence Erlbaum Associates.

In the second half of the 19th century, the nature of biological inheritance was hotly discussed in scientific circles.[7] During that time, Charles Darwin (1809-1882) proposed his famous theory of evolution by means of natural selection. Darwin, who was Galton's first cousin, articulated this theory in his book, *On the Origin of Species*, published in 1859. The process of natural selection is based on variation in living organisms. Organisms with the behavioral and physical characteristics necessary to cope with the environment survive and reproduce while other organisms do not.[8] Darwin's book helped frame Galton's ideas about heredity. Specifically, Galton saw Darwin's theory of evolution as a guide to improve human society.[9]

In addition to Darwin's theory of evolution, Galton was influenced by Victorian scientific naturalism.[10] Scientific naturalism is the notion that all phenomena can be explained in terms of natural causes and laws without attributing moral, spiritual, or supernatural significance to them. Naturalism originated with the rise of science in the 17th and 18th centuries.

Opponents of naturalism viewed this approach as an attack on traditional authority.[11] The scientific naturalism espoused by writers such as Jean Jacques Rousseau (1712-1778) threatened kings, priests, and autocrats whose authority rested on tradition and instinct rather than reason. Thus, the battle was not just about intellectual abstractions but about who should have authority and who should enjoy the material advantages that flow from the possession of that authority.[12] Scientific naturalism was a weapon of the middle class in its struggle for power since scientific naturalism based power and authority on merit and professional elitism, rather than patronage or nobility.[13]

In 1869 Galton wrote one of his most famous books, *Hereditary Genius*. In this book and in *English Men of Science*, published in 1874, Galton expanded on his view that ability and intellectual power are innately rather than environmentally determined.[14] Galton based this conclusion on family tree data of intellectually prominent individuals.[15] He found that people known for their intellect tended to have more famous relatives than other individuals. Based on this finding, Galton believed that the factors underlying human intelligence are biologically inherited.[16] As a corollary to this belief, Galton felt that social agencies should encourage superior individuals to procreate and should discourage "breeding" among those with

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[7] Ibid.
[8] Darwin, C. (1859). *On the origin of the species.* New York: The New American Library.
[9] Gale Group (2001). *Gale Encyclopedia of Psychology*, 2nd ed. < http://www.findarticles.com/cf_dls/g2699/0001/2699000146/p1>
[10] Cowles, M. (1989). *Statistics in Psychology: An Historical Perspective.* Hillsdale, NJ: Lawrence Erlbaum Associates.
[11] Ibid.
[12] MacKenzie, D. A. (1981). *Statistics in Britain 1865-1930.* Edinburgh: Edinburgh University Press.
[13] Cowles, M. (1989). *Statistics in Psychology: An Historical Perspective.* Hillsdale, NJ: Lawrence Erlbaum Associates.
[14] Galton, F. (1869). *Hereditary genius.* London: MacMillian; Galton, F. (1874). *English men of science.* London: MacMillian,
[15] Locy, W. W. (1908). *Biology and its Makers.* New York: Henry Holt and Company.
[16] Forestt, D. W. (1995). *Francis Galton. Seven Pioneers of Psychology.* New York: Routledge.

little "civic worth."[17] This set of beliefs gave rise to the Eugenics Movement.[18] Galton coined the term eugenics to represent the scientific attempt to improve human society through selective parenthood.

Despite his findings, Galton was dissatisfied that he had to use largely qualitative rather than quantitative data to support his arguments for intellectual heredity. Galton was a collector of measurements to an almost compulsive degree.[19] He wanted to be able to take precise measurements of parents and their offspring and examine the potential relations among these measurements more directly.

In science, the quantification of information had become increasingly important by that time. The popular belief was that an understanding of phenomena in the natural world was best achieved by *measurement.* Measurement was viewed as the link between mathematics and science, offering scientists a sense of mathematical clarity and order.[20] Galton's belief in the central importance of measurement was demonstrated by his support for the statement:

> Until the phenomena of any branch of knowledge have been submitted to measurement and number, it cannot assume the status and dignity of a Science.[21]

To support his views, Galton set about collecting data.[22] At first, he bred sweet peas and examined their size over two generations. When the size of a parent seed was compared with the average size of the offspring seeds, Galton observed what he called *regression to the mean*.[23] Specifically, the average (mean) size of the offspring seeds was not as extreme as the size of the parent seed. For example, the offspring seeds of abnormally large parent seeds tended to be larger than average, but not as large as the parent seed. Similarly, below average parent seeds spawned seeds that were small but not as small on average as the parent seeds.

However, Galton was not really interested in sweet pea seeds. He later remarked:

> It was anthropological evidence that I desired, caring only for the seeds as means of throwing light on heredity in man. I tried in vain for a long and weary time to obtain it in sufficient abundance.[24]

In an effort to acquire data from multiple generations of humans, Galton opened an anthropometric laboratory in 1884. For a small fee, members of the general public were admitted to the

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[17] Cowles, M. (1989). *Statistics in Psychology: An Historical Perspective.* Hillsdale, NJ: Lawrence Erlbaum Associates.
[18] Jones, L. (1998). Social Darwinism revisited. *History Today.* < http://www.findarticles.com/cf_dls/m1373/n8_v48/21031902/p1>
[19] Cowles, M. (1989). *Statistics in Psychology: An Historical Perspective.* Hillsdale, NJ: Lawrence Erlbaum Associates.
[20] Cowles, M. (1989). *Statistics in Psychology: An Historical Perspective.* Hillsdale, NJ: Lawrence Erlbaum Associates.
[21] Ibid.
[22] Galton, F. (1908). *Memories of My Life.* London: Methuen.
[23] Galton, F. (1977). Typical laws of heredity. *Proceedings of the Royal Institution of Great Britain, 8,* 282-301.
[24] Galton, F. (1885a). Regression toward mediocrity in hereditary stature. *Journal of the Anthropological Institute of Great Britain and Ireland, 14,* 246-263, p. 247.

Laboratory.[25] In return, the visitors received a record of their various physical characteristics, measures of strength, and sensory and perception abilities.[26] Thousands of people visited the Laboratory, providing Galton with the data he needed. Among many other things, he was able to examine the relation between the heights of parents and their adult children. To do so, for each full grown child Galton calculated the midparent height by averaging the height of his or her parents. Galton then organized these data by creating a chart with midparent height along the horizontal axis and the adult children's height on the vertical axis (See Table 1)[27]. Based on these data, Galton concluded that children possessed traits exhibited by their parents, but those traits tended to be less extreme than those of their parents.[28] Consequently, instead of increasing in superiority, successive generations had a tendency to be increasingly average. Galton termed this apparent phenomenon as *regression toward mediocrity*.[29] Additionally, in examining the chart he created, Galton perceived that he could summarize the data with a line showing how adult children's heights related to their parents' heights.[30] This line, which developed into what is now known as the *regression line*, could be used to make predictions about children's heights in adulthood based solely on information from their parents.

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[25] Hothersall, D. (1995). *History of Psychology.* New York: McGraw-Hill, Inc.
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[28] Galton, F. (1885b). Opening address to the Anthropological Section of the British Association by the president of the section. *Nature, 32,* 507-510.
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[30] Cowles, M. (1989). *Statistics in Psychology: An Historical Perspective.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Table 1. Galton's data on Midparent Height and Height of Adult Children[31]

Height of Adult Children (in.)	Midparent Height (in.)										
	Below 64	64-65	65-66	66-67	67-68	68-69	69-70	70-71	71-72	72-73	Above 73
Above 74							5	3	2	4	
73-74						3	4	3	2	2	**3**
72-73			1		4	4	11	4	9	**7**	
71-72			2		11	18	20	7	4	2	
70-71			5	4	19	21	25	14	**10**	1	
69-70	1	2	7	13	38	48	**33**	**18**	5	2	
68-69	1		7	14	28	**34**	20	12	3	1	
67-68	2	5	**11**	**17**	**38**	31	27	3	4		
66-67	2	**5**	11	17	36	25	17	1	3		
65-66	1	1	7	2	15	16	4	1	1		
64-65	**4**	4	5	5	14	11	16				
63-64	2	4	9	3	5	7	1	1			
62-63		1		3	3						
Below 62	1	1	1			1		1			

Note: Bolded cells indicate the middle 50% of the data.

[31] Table adapted from Minium, E. W., King, B. M., & Bear, G. (1993). *Statistical Reasoning in Psychology and Education.* (3rd ed). New York: John Wiley & Sons, Inc.

Using Regression to Make Predictions

Although Francis Galton is credited with the basic conceptualization of regression, others like Karl Pearson (1857-1936) expanded on Galton’s work resulting in the widespread use of regression (Minium, King, Bear, 1993). Today, regression analysis is often used to make predictions about an unknown variable based on a known variable or many known variables. *Simple regression* refers to the use of one variable to predict another. For example, a father’s height could be used to predict the height of his future son. *Multiple regression* refers to the use of several variables (e.g., father’s height, mother’s height, and diet) to predict another variable (e.g., son’s height; Pedhazur, 1997). Here we focus on simple regression.

To use regression to make predictions, a regression model must be developed with existing data (Minium et al., 1993). For instance, height data from numerous fathers and adult sons might be used to develop a regression model that predicts of the height of future sons. These data (i.e., the height of each father and a son) need to be paired so that a father’s height is linked to his son’s height (Figure 1a). In statistics, the variable used to predict another variable is represented with the symbol X and is referred to as the *independent* variable, the *predictor* variable, or the *exogenous* variable. The variable to be predicted is represented with the symbol Y and is referred to as the *dependent* variable, the *criterion* variable, or the *endogenous* variable (Pedhazur, 1997). In the current example, father’s height is the independent variable (X) and son’s height is the dependent variable (Y).

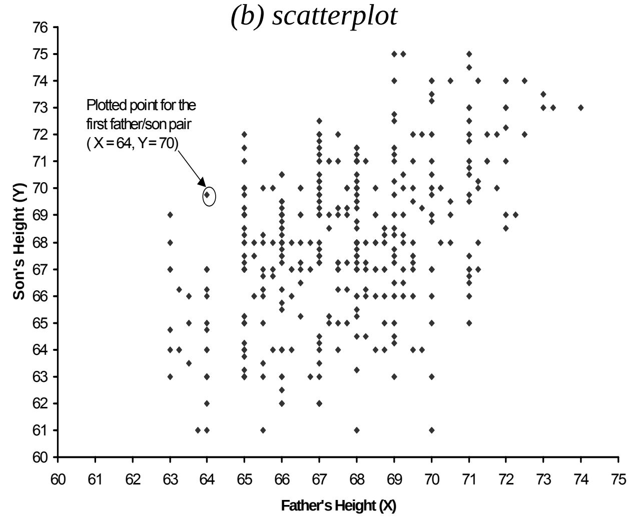
The paired data can be graphically represented in a *scatterplot* (Figure 1b). As with Galton’s table shown previously in Table 1, graphs usually have two axes: horizontal and vertical. The horizontal axis is called the *abscissa* or X-axis and the vertical axis is called the *ordinate* or Y-axis. The data for each father/son pair are represented with a point in the plot located at the intersection of the X and Y values. For example, for the first father/son pair the point is placed on the scale above 64 inches on the X-axis and to the right of 70 inches on the Y-axis (Figure 1b).

Figure 1. Father and son height data.

(a) paired data

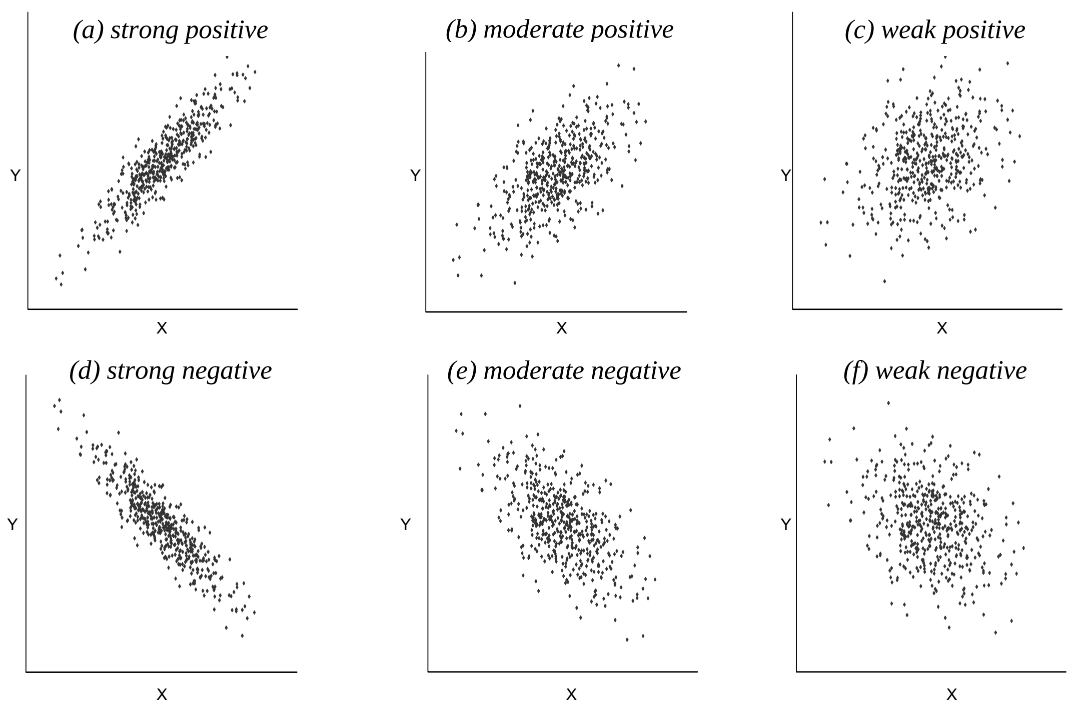
Father’s Height (X)	Son’s Height (Y)
64	70
69	69
72	71
65	67
70	72
.	.

(b) scatterplot



A scatterplot reveals important information about the relation between two variables (Minium et al., 1997). For instance, the scatterplot can be used to determine if there appears to be a *linear relation* between the variables. The regression procedures developed by Galton and Pearson assume that the variables of interest are linearly related to one another (Minium et al., 1997). Two variables are linearly related if the points in the scatterplot ascend or descend in a manner that follows a fairly straight line (Bartz,1993). Further, specific terms are used to describe the relation between the variables. When the cluster of points tilts from the lower left to the upper right (ascending), there is a *positive* relation (or positive *slope*) between the variables (i.e., Figures 2a, 2b, and 2c). This indicates that as the X variable increases, the Y variable also tends to increase. When the cluster of points slopes from the upper left to the lower right (descending), there is a *negative* relation (or negative slope) between the variables (i.e., Figures 2d, 2e, and 2f). This indicates that as the X variable increases, Y tends to decrease. If there is a *perfect positive* linear relation or a *perfect negative* linear relation between two variables, all of the points in the scatterplot will lie in a straight line. In most cases, the relation between two variables is not perfect and the majority of the points lie above and below a perfectly straight line.

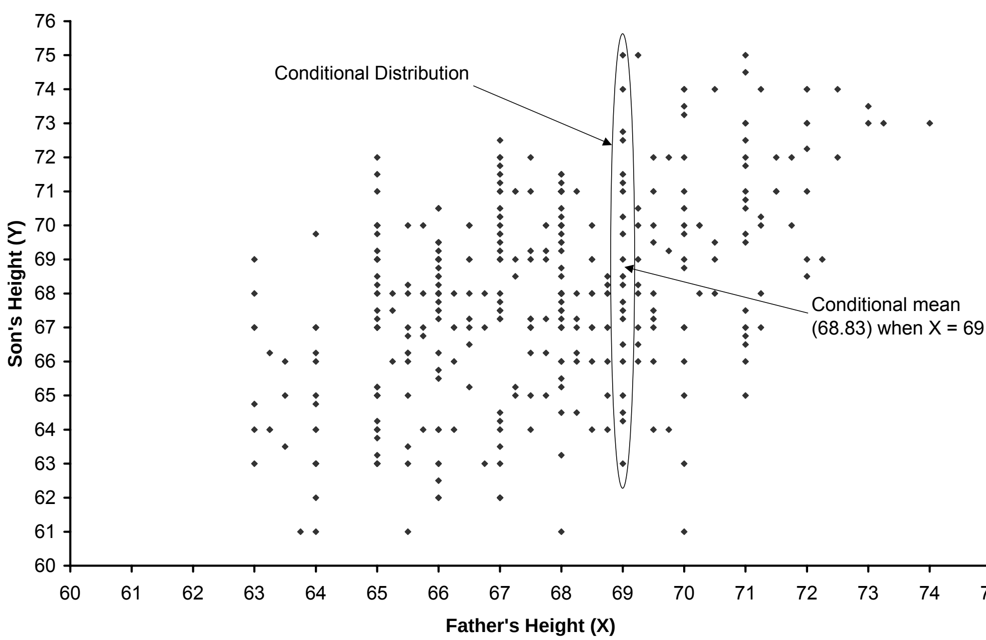
Figure 2. Scatterplots of positive and negative linear relations of varying strengths.



The degree to which the points in the scatterplot deviate from a straight line is related to the *strength* of the relation between two variables (Bartz, 1999). When there is a *strong* relation between two variables the points will ascend or descend in a systematic manner that is well approximated by a straight line (i.e., Figures 2a and 2d). If there is a *moderate* relation, the points in the scatterplot will still appear to ascend or descend in a systematic manner but they will be more spread out (i.e., Figures 2b and 2e). A *weak* relation is indicated when the points are highly spread out with little discernable ascending or descending pattern (i.e., Figures 2c and 2f). For the data on fathers' and sons' heights (Figure 1b), there appears to be a moderate positive relation between the two variables.

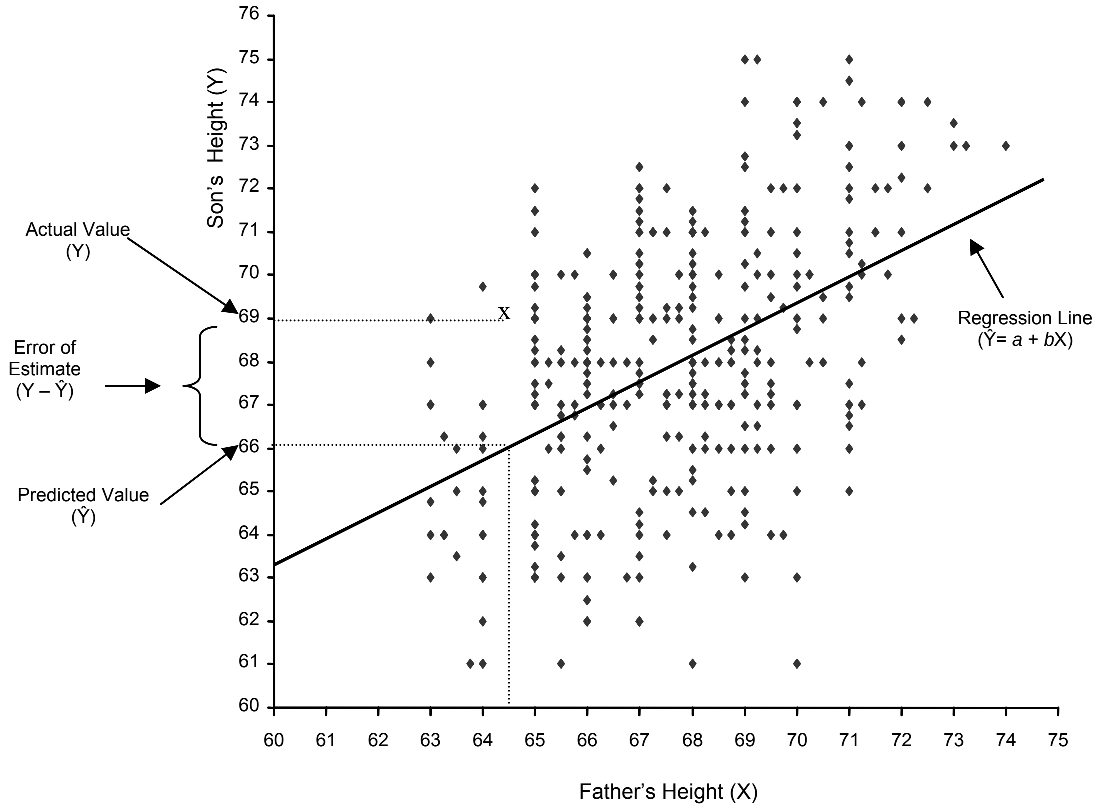
By examining the scatterplot for fathers and sons, it is evident that for each value of X there is not just a single value of Y, but rather a vertical distribution of Y values. For example, in these data fathers who are 69 inches tall have grown sons who are between 63 and 75 inches tall (Figure 3). The distribution of Y values for a specific value of X is referred to as the *conditional distribution*. For each conditional distribution, there is also a *conditional mean*. The conditional mean represents the average Y score for a particular value of X. In the father and son example, when X = 69 inches the conditional mean for Y is 68.83 inches (Figure 3). This was calculated by summing all of the sons' heights (Y values) when X = 69 and dividing by the number of Y values in that conditional distribution. Consequently, if a 69 inch tall prospective father were to ask how tall his son is likely to be, a reasonable prediction would be 68.83 inches. This represents the average height of sons whose fathers are 69 inches tall.

Figure 3. Scatterplot with conditional distribution and conditional mean.



If a prospective father's height is not specified in the distribution but falls above, below, or between the heights recorded (e.g., 60, 75, or 64.50), a conditional mean is not directly available. Still, a prediction can be made. Specifically, a line can be drawn that approximately connects the conditional means of Y values for which there are data and that extends beyond the plotted X values (Figure 4). This line is referred to as the *regression line*. Consequently, for any value of X (whether observed in the data or not) there is a corresponding Y value along the regression line that serves as the predicted value of Y for that X (Figure 4). For example, using the regression line, if a father is 64.50 inches tall, his son will be predicted to be approximately 66 inches tall. This prediction is made by locating 64.50 on the X-axis, drawing a line up to the regression line, and then over to the Y-axis (Figure 4).

Figure 4. Scatterplot with regression line and error of estimate.



In addition to diagrammatically, the regression line can be represented mathematically with the *regression equation:*

$$\hat{Y} = a + bX$$

In this equation, $\hat{Y}$ represents the predicted Y value for a given X, *a* represents the *intercept* (i.e., where the line intercepts the Y axis when X=0), and *b* represents the steepness or *slope* of the line (i.e., the line's change in the Y direction for every one unit increase in the X direction). If the slope is a positive value, there is a positive relation between the variables. If the slope is a negative value, there is a negative relation between the variables. If the slope is zero, there is no linear relation between the variables. Once *a* and *b* are determined through a series of calculations (not shown here), a predicted Y value ($\hat{Y}$) can be calculated for any X value. For instance, based on the father and son height data, the intercept and slope are $a = 26.02$ and $b = .62$, respectively. These values may in turn be placed in the regression equation, yielding $\hat{Y} = 26.02 + .62X$. Thus, using the regression equation, the 64.50 inch father would be predicted to have a son who is 66.01 inches tall [i.e., 66.01 = 26.02 + .62(64.50)].

When using regression to make predictions, the actual Y value will usually be different from the predicted Y. For example, although a 64.50 inch tall father may be predicted to have a son who is 66.01 inches tall, the son may actually grow to be, say, 69 inches tall (Figure 4). The discrepancy between the actual and predicted Y values is referred to as *error of estimate* and is mathematically represented as $Y - \hat{Y}$ (Bartz, 1999). Thus, for a 64.50 inch tall father who has a 69 inch tall son, the error of estimate is $Y - \hat{Y} = 69 - 66.01 = 2.99$ inches (Figure 4).

For any regression model, the accuracy of the prediction depends on the strength of the relation between the two variables. When the independent and dependent variables are strongly related, there tends to be less deviation from the regression line (i.e., less error of estimate, $Y - \hat{Y}$). Consequently, predictions tend to be more accurate. If the relation between two variables is moderate or weak, predictions tend to be less accurate (i.e., more error of estimate) than when there is a strong relation between variables.

Today, regression is commonly used to make predictions in various fields, including education, psychology, and other social sciences. Such widespread use of regression would not have been possible without Sir Francis Galton. Thus, although Galton was primarily interested in heredity and other phenomena in the natural world, he influenced numerous fields by providing the conceptual foundation for this major statistical technique.

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Appendix F

Strategy Inventory

Study ID # __________________

Please check (√)the strategies that you use in order to help you comprehend and remember the passage, and place an asterisk (*) next to those that were MOST helpful.

1. ______reread parts of the passage
2. ______skipped difficult parts of the passage
3. ______skipped boring parts of the passage
4. ______changed my reading rate
5. ______questioned information in the text
6. ______created mental images of what I read
7. ______rehearsed the main idea
8. ______critiqued the information based on my prior knowledge
9. ______reflected on the reading
10. ______looked for salient details
11. ______created personal examples
12. ______mentally summarized the text
13. ______related to information to what I already knew
14. ______rephrased main ideas in my own words
15. ______elaborated on the main idea
16. ______ignored words or phrases not critical to understanding
17. ______used context to determine meaning
18. ______took notes
19. ______assessed the credibility of the cited authors
20. ______underlined important information
21. ______other

Appendix G

Knowledge Tests

Study ID # ___________________

Directions: For each item, circle the response that is MOST appropriate. Do NOT use any of the other materials in the packet to answer the items.

1. Galton was knighted for his accomplishments in a diverse range of fields in _____.
   a. 1869
   b. 1884
   c. 1909
   d. 1921

2. Interest in which of the following contributed to Galton's conceptualization of regression?
   a. heredity and scientific naturalism
   b. heredity and statistics
   c. measurement and scientific naturalism
   d. measurement and statistics

3. Which of the following is an example of natural selection?
   a. Giraffes have long necks because they like to stretch.
   b. Lap dogs are small because of selective breeding.
   c. Rats are more common in cities because food is available.
   d. Zebras are fast because the slow ones get eaten.

4. Which of the following statements is most consistent with Victorian scientific naturalism?
   a. "Events and phenomena can be attributed to scientific laws and natural causes."
   b. "Power and authority should clearly rest in the hands of kings and noblemen."
   c. "Science should be used as a means for humans to return to their natural state."
   d. "Unexplained events are due to spiritual forces trying to maintain a moral code."

Study ID # ________________

5. In his studies on heredity, Galton wanted quantitative data because:
    a. at that time, Galton had a large collection of measurement tools and wanted to use them.
    b. during his time, measurement was seen as a way to gain mathematical clarity and order.
    c. Galton wanted his work to have more in common with the work of Charles Darwin.
    d. this form of data was the most difficult to obtain and Galton enjoyed the challenge.

6. Based on Galton's views, which of the following events would he find surprising?
    a. A child is more similar to his adopted parents than to his biological parents.
    b. A child learns to walk at the same age her mother learned to walk as a child.
    c. An accomplished composer is the daughter of a world famous musician.
    d. Identical twins who are raised apart have similar physical and mental abilities.

7. Galton began his investigations on sweet peas in order to:
    a. develop new, sophisticated statistical concepts (e.g., regression).
    b. learn about heredity and apply this understanding to humans.
    c. understand the life cycle of plants and create better peas.
    d. understand the relation between the weight and size of peas.

8. The scientific attempt to improve society through selective parenthood is referred to as ____________.
    a. eugenics
    b. evolution
    c. regression
    d. scientific naturalism

9. Galton is credited with the phrase, "Whenever you can, count." This is characteristic of Galton's:
    a. abilities with statistics.
    b. aptitude for mathematics.
    c. interest in measurement.
    d. fascination with numbers.

10. Which of the following social programs would Galton most likely support?
    a. Educational policies requiring that all children be taught to read by age nine.
    b. Mandatory birth control for women receiving welfare.
    c. Mandatory pre-school education for all children.
    d. State-funded support for teen-parents who have dropped out of school.

Study ID # __________________

11. The *primary* purpose of Galton's anthropometric laboratory was to:
    a. offer Galton the opportunity to raise money for his research.
    b. offer people the opportunity to engage in scientific experiments.
    c. provide Galton with information about parents and their children.
    d. provide people with a record of information about themselves.

12. A regression line is *most* often used to
    a. interpret hypotheses.
    b. make predictions.
    c. prove relationships.
    d. support conclusions.

13. Why do researchers rely on statistical procedures?
    a. To establish a level of objectivity in scientific fields.
    b. To manipulate data in an effort to change the social order.
    c. To provide subjective information to policy makers.
    d. To reduce large amounts of data to meaningful values.

14. How would you characterize Yule and Kendall's perspective on the use of the term *regression* to refer to prediction?
    a. Because students are sometimes confused, the term is inappropriate.
    b. Due to its current use, attempts to use a different term would be futile.
    c. It is unfortunate and efforts should be made to use a different term.
    d. Researchers should be educated on the correct uses of the term.

15. Galton is known for his accomplishments in such areas as meteorology, biology, and psychology. For example, in one study he examined the size of sweet pea seeds over successive generations. In another investigation, he explored the relation between the heights of parents and their children. Which of the following statements is the most appropriate characterization of his work in these two areas?
    a. In both studies, data revealed that the offspring tended to be less extreme than their parents.
    b. In both studies, there was no significant relation between parent organisms and their offspring.
    c. In the human study, the evidence was less conclusive than in the sweet pea research.
    d. In the human study, the results contradicted what Galton found in the sweet pea study.

Study ID # ________________

Directions: For each item, circle the response that is MOST appropriate. Do NOT use any of the other materials in the packet to answer the items.

1. In a scatterplot, the X-axis can also be referred to as the ________.
   a. abscissa
   b. ordinate
   c. dependent axis
   d. criterion axis

2. A researcher wants to predict students' college GPA based on their SAT scores. Students' GPA scores would be the __________ variable.
   a. abscissa
   b. endogenous
   c. exogenous
   d. predictor

3. In simple regression, how many independent variables are used?
   a. None
   b. One
   c. More than one
   d. It depends on the situation.

4. In order to use regression to make a prediction, what needs to be done *first*?
   a. Determine the error of estimate for a specific observation.
   b. Develop a regression model based on existing data.
   c. Locate two variables that have a perfect linear relation.
   d. Use the regression equation to calculate a predicted value.

5. Regression procedures are based on the assumption that:
   a. several variables are used to predict another variable.
   b. the variables are conditionally related to one another.
   c. the variables are linearly related to one another.
   d. the variables are vertically related to one another.

6. The term *conditional distribution* refers to the distribution of:
   a. X values for a specific value of Y.
   b. predicted Y values (i.e., $\hat{Y}$ values).
   c. Y values for a specific value of X.
   d. $\hat{Y}$ values for a specific value of X.

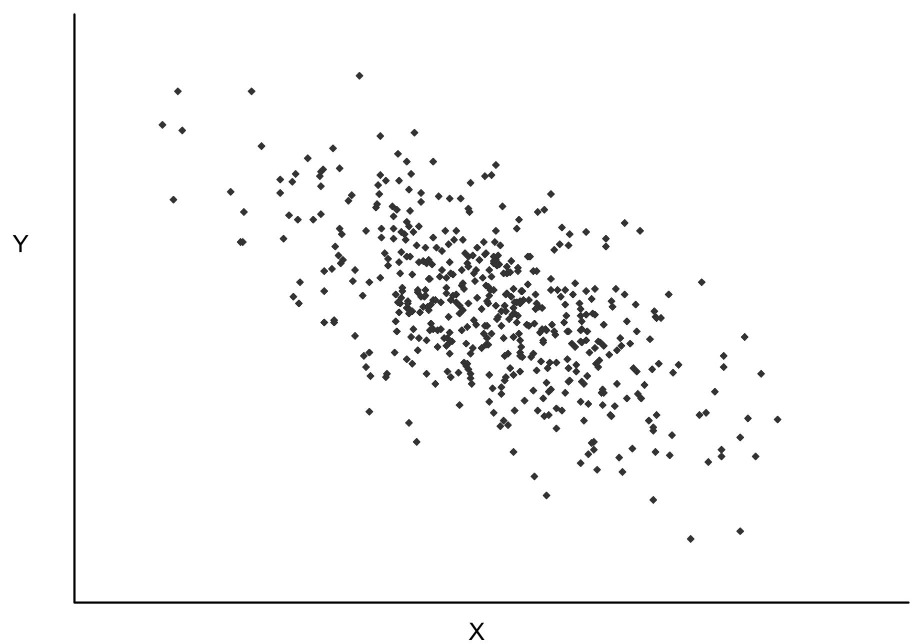
Study ID # ___________________

7. If the intercept of a line equals 10 and the slope is 5, which of the following represents the regression equation?

   a. $\hat{Y} = 10X - 5$
   b. $\hat{Y} = 10 + 5X$
   c. $\hat{Y} = 5 + 10X$
   d. $\hat{Y} = 10X + 5Y$

8. Based on the scatterplot below, what can you conclude about the nature of the relationship between the variables?

   a. There is a moderate negative relation between the variables.
   b. There is a moderate positive relation between the variables.
   c. There is a strong negative relation between the variables.
   d. There is a strong positive relation between the variables.



Study ID # __________________

9. Using a scatterplot, a researcher determines that there appears to be a weak positive relation between height and mechanical abilities. He concludes that using individuals' height to predict their mechanical abilities will lead to small errors of estimate. This conclusion is:

   a. correct because when variables are weakly related predictions tend to be more accurate.
   b. correct because when variables are weakly related there is more variation from the regression line.
   c. incorrect because when variables are weakly related predictions tend to be less accurate.
   d. incorrect because when variables are weakly related points have less deviation around the regression line.

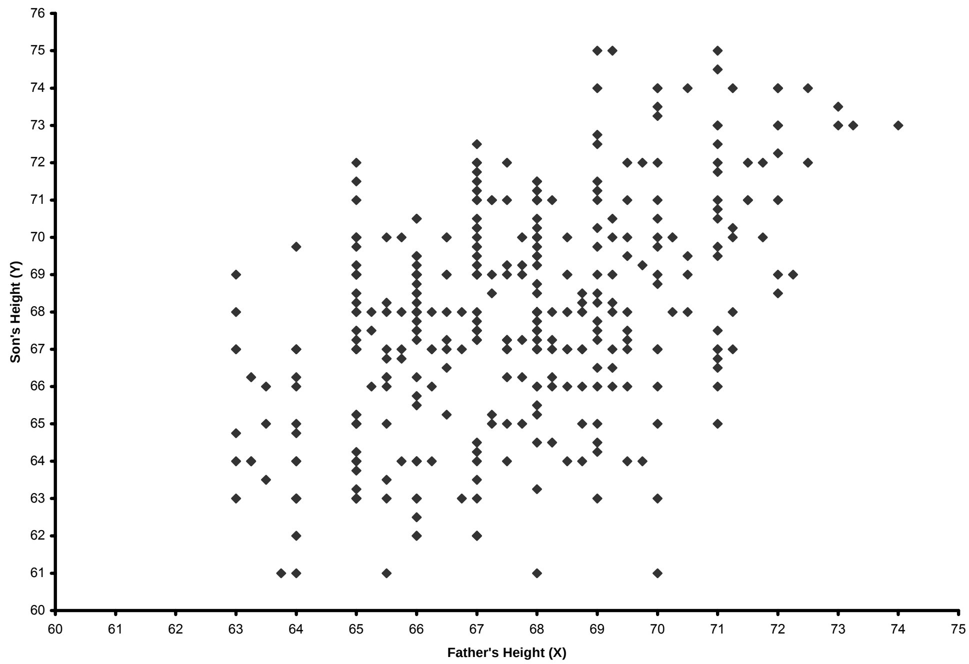
10. Bill and Hillary are expecting a baby boy. Bill is 73 inches tall, making the predicted height for their future son (using a regression equation) 72 inches. These results can roughly be interpreted to mean that:

   a. their son will be 72 inches tall.
   b. 72 is the average height of all sons.
   c. there is a strong relation between father’s height and son’s height.
   d. 72 inches is the average son’s height for fathers who are 73 inches tall.

11. A researcher determines the regression line for predicting life expectancy from cholesterol level, finding that the slope has a negative value. If she uses a regression equation to predict the life expectancy for someone with a <u>low</u> cholesterol level, that person would be predicted to have

   a. a below average life expectancy for those studied
   b. an average life expectancy for those studied.
   c. an above average life expectancy for those studied.
   d. Not enough information to answer this question.

Study ID # __________________



12. Using the above scatterplot, if a father is 65 inches tall, what would be the *best approximation* for the conditional mean?

    a. 64 inches
    b. 67 inches
    c. 70 inches
    d. 72 inches

---

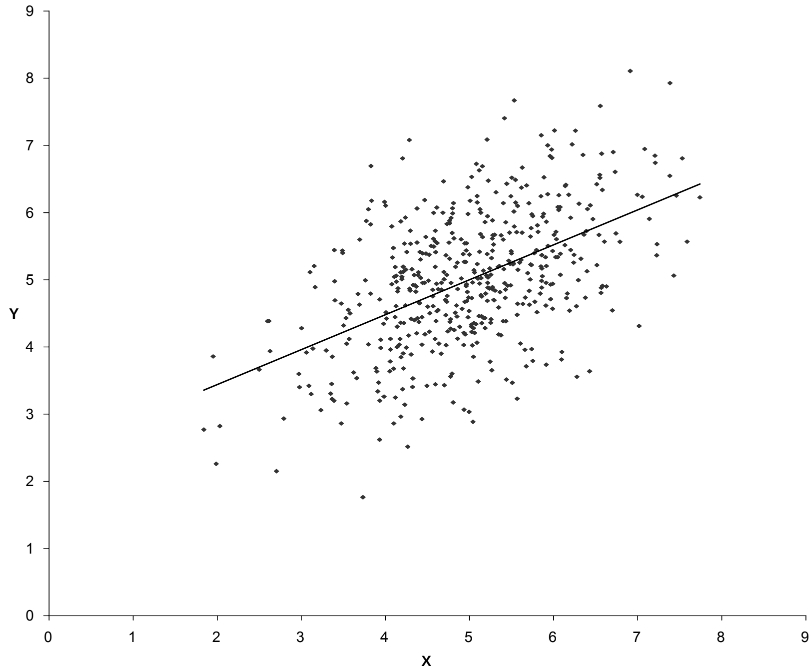
13. Using regression, a school administrator predicts that a student will graduate from college with a GPA of 3.00 on a 4.00 scale. The student actually graduates with a 3.40 GPA. The error of estimate is:

    a. .10
    b. .40
    c. .60
    d. Not enough information to determine the error of estimate.

14. After conducting a study, you find that X and Y have a perfect linear relation. Thus, someone with a high score on X would be predicted to have:

    a. a below average score on Y.
    b. an average score on Y.
    c. an above average score on Y.
    d. Not enough information to answer this question.

Study ID # ___________________



15. Using the above scatterplot, if X = 3, what is an appropriate prediction for Y?

a. 3.0
b. 3.5
c. 4.0
d. 4.5

Appendix H

Intentions Measure

Study ID # ____________________

Activities Related to Mathematics and History How likely are you to engage in each of the following activities in the future?	Not Very Likely … Very Likely
1. Take a history-related course.	0----1----2----3----4----5----6----7----8----9
2. Choose to learn more about mathematics.	0----1----2----3----4----5----6----7----8----9
3. Read a historical book.	0----1----2----3----4----5----6----7----8----9
4. Pursue a history-related career.	0----1----2----3----4----5----6----7----8----9
5. Take a mathematics-related course.	0----1----2----3----4----5----6----7----8----9
6. Choose to learn more about history.	0----1----2----3----4----5----6----7----8----9
7. Pursue a mathematics-related career.	0----1----2----3----4----5----6----7----8----9
8. Read a book about mathematics.	0----1----2----3----4----5----6----7----8----9

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