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The Role of Academic Confidence and Epistemological Beliefs on Syllogistic Reasoning Performance

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In its simplest form, syllogisms are deductive reasoning problems consisting of two related statements (premises) and a conclusion. A popular example of a syllogism is:

All men are mortal.

Socrates is a man.

Therefore, Socrates is mortal.

To engage in syllogistic reasoning one must understand the concept of groups (sets), and set memberships. In this example, Socrates belongs to the set "men", which in turn, belongs to the set "mortal"; based on these two set memberships, we can validly conclude that "Socrates is mortal". Syllogisms, like the above example, contain quantifiers such as "all", "some", "none" and "most". In everyday life, people utilize and are exposed to shorter forms of syllogistic reasoning where a premise is often implied rather than stated (Kirby & Goodpaster, 2007). For example, a Canadian citizen might claim that:

Michaëlle Jean is the Governor General of Canada.

Therefore, she deserves respect.

The complete syllogism for this claim would be:

All Governor Generals of Canada deserve respect.

Michaëlle Jean is the Governor General of Canada.

Therefore, she is a person who deserves respect.

We use syllogistic reasoning to evaluate the truthfulness of individual statements, to interpret the relationship between statements, and to determine whether a proposed conclusion is valid. In the real world, syllogistic reasoning is necessary for understanding societal rules and regulations, and for critically analyzing information from the news, media, and advertisements (Skuy & Mentis,

1999). In short, we require syllogistic reasoning skills for determining the validity of everyday assumptions, assertions, and conclusions.

From elementary school to university, educators are aware of the positive link between formal logic skills and academic performance (Halpern, 1997). Although this link is known, the domain of formal logic is not taught in North America until undergraduate university. Syllogistic reasoning is at the heart of critical or logical thinking in academic courses. Acquiring formal thinking skills is required for success in mathematics, sciences, and humanities as it allows students to formulate and test hypotheses from which specific conclusions can be deducted. Altogether, the idea that these disciplines are a form of syllogistic reasoning may be too strong, but certainly academic success involves different levels of syllogistic reasoning.

From the 1970s to the 1990s, cognitive psychologists examining individual differences in syllogistic reasoning have mostly focused on information-processing frameworks such as the mental model theory (Johnson-Laird, 1983), the formal rules theory (Rips, 1994), and the probability heuristics model (Chater & Oaksford, 1999). Such research has assisted in identifying cognitive variables associated with optimal syllogistic reasoning (Bara & Bucciarelli, 1995). For example, Bara and Bucciarelli (1995) found that working memory and ability to identify similar objects within figures explained 39% of the variance in syllogistic reasoning performance among children, adolescents, and adults. While these studies were helpful in discovering cognitive variables related to syllogistic reasoning, they did not entirely explain why some individuals reason or think better than others. Jensen (1998) found that the correlation between IQ (a standardized measure of cognitive ability) and academic performance is approximately 0.50 which translates to 25% of the variance in academic performance being accounted for by IQ. Hence, 75% of the variance in academic achievement remains to be explained by other variables. These

additional variables may be characterized as non-cognitive, personal, or social constructs or traits that influence academic achievement.

Richard E. Snow (1936-1997), an eminent psychologist in educational assessment, posited a multi-systems theory for understanding individual differences in academic task performance (Shavelson et al., 2002). Snow believed that academic performance is a dynamic process involving a continuous interplay between the characteristics of the individual and the learning or testing situation. For example, a student has certain resources (mental/emotional aptitudes, domain knowledge, instructional experiences, etc.) that interact with an academic setting to produce a certain kind of learning and test performance. Snow outlined three aptitudes that students may bring into an academic situation: (1) "cognitive" (e.g., verbal, quantitative), (2) "affective" (e.g., temperament, emotion), and (3) "conative" (e.g., motivation, volition) processes (Shavelson et al., 2002). Affective and conative variables are also known as "motivational" processes (Kupermintz, 2002). While Snow's multivariate approach was developed to improve the valid interpretation of achievement test scores, his ideas can be applied to understanding academic achievement in general.

In line with Snow's multi-systems theory, educational researchers are constructing "local" theories of self-related variables including affective and conative proclivities that influence syllogistic reasoning (e.g., Blanchette & Richards, 2004; Smith & Levin, 1996; St. B.T. Evans, 2003). Their studies focus on student-centred variables such as need for cognition (Smith & Levin, 1996), belief biases (St. B.T. Evans, 2003), and emotions (Blanchette & Richards, 2004). These studies demonstrate that assessing self-related variables (in addition to cognitive aptitudes) are critical for explaining academic learning and achievement. Based on Snow's multivariate model, understanding the dynamics between students' aptitudes and the learning/testing climate in which these aptitudes function is important for predicting academic outcome.

Furthermore, Snow's approach suggests that outlining the relationship *among* conative variables is also critical. The idea that conative variables interact with each other may be applied to the formal logic domain—that is, by investigating how conative variables *together* produce different levels of logical reasoning, we stand a better chance of creating effective educational programs.

To our knowledge, no research has been conducted on the role of conative variables such as *academic confidence* and *epistemological beliefs* on performance in formal logic courses. Since formal logic is first taught at the undergraduate level in North America, we extended research on academic confidence and epistemological beliefs into this domain. These two conative variables were found to have a strong, positive link with academic performance (e.g., Pajares, 1996; Schommer, 1994). To set the context for our present study, we review research findings in academic confidence and epistemological beliefs, and how they may relate to the acquisition of syllogistic reasoning skills.

Academic Confidence

Bandura (1986, 1993) defined self-confidence or self-efficacy as a belief in one's ability to successfully perform an action or achieve a certain goal. Self-confidence can originate from the mastery of skills, vicarious experiences, social invitations, and social/emotional support (Britner & Pajares, 2006; Madewell & Shaughnessy, 2003; Pajares, 2000). Self-confidence is tied to academic agency, effort, motivation, and initiating and pursuing academic goals (Pajares, 2000). Furthermore, a positive relationship exists between confidence and academic performance (Pajares, 2000), in addition to academic resiliency (Martin & Marsh, 2006).

Creating academic goals, applying learning strategies, and monitoring the learning outcome are inherent processes of self-regulated learning (Butler & Winne, 1995; Winne, 1997, 2005). Pintrich and De Groot (1990) showed that a greater sense of academic confidence is related to higher levels of self-regulation by middle school students in mathematics and in English.

Furthermore, higher levels of confidence significantly correlated with effective learning strategy use (Pintrich & De Groot, 1990; Zimmerman & Martinez-Pons, 1990). Hence, confidence (such as expectations of high achievement) and self-regulated learning (such as monitoring the outcome of using certain learning strategies) are positively associated with one another.

Academic confidence and social confidence were also found to positively correlate with academic performance by high school students (Tavani & Losh, 2003). A meta-analysis uncovered that confidence predicted academic performance and persistence across disciplines, particularly for high school and university students (Multon, Brown, & Lent, 1991). Some investigators have looked at the role of confidence in language arts programs where confidence in one's writing abilities was positively related to writing performance by undergraduate students (Pajares & Johnson, 1993). Confidence is also positively related to performance in undergraduate courses such as biology (Lawson, Banks, & Logvin, 2007). Furthermore, research suggests that domain-specific measures of confidence tend to predict and explain academic outcomes better than more domain-general measures (Pajares, 1996).

Based on the above research, we can state, overall, that academic confidence is related to setting and achieving school-related goals by high school and university students. Results, however, are mixed in terms of the connection between academic confidence and cognitive abilities on scholastic performance. One study found that IQ scores and level of confidence were uncorrelated, and that IQ was the best predictor of academic achievement (Gagne & St. Père, 2001). In contrast, another study found that while cognitive ability was the strongest predictor of science achievement, confidence predicted science achievement variance above and beyond cognitive ability (Lau & Roeser, 2002).

The finding by Gagne and St. Père (2001) that cognitive ability and confidence level are independent, and that cognitive ability is the best

predictor of academic achievement does not necessarily mean that confidence cannot help to predict academic performance. It would be difficult to believe that students with similar IQ scores but different confidence levels (e.g., one student with a high level of confidence, the other with a low confidence level) would perform similarly on academic tasks. Moreover, as noted by Gagne and St. Père, their findings may be due to brighter students being less motivated as a result of an unchallenging high school curriculum; hence, in their study, the brighter students were able to highly achieve with little motivation. Overall, we agree that cognitive ability needs to be addressed when examining the impact of conative variables on academic performance. Our present study was conducted with the hypothesis that confidence is an important contributor to logical thinking (syllogistic reasoning) performance, in addition to cognitive ability.

For this study, we hypothesized that student confidence would be positively affiliated with syllogistic reasoning performance. Based on Snow's multidimensional model, we were also interested in how student confidence might interact with other conative variables in predicting syllogistic reasoning performance. That is, we were aware that a high level of confidence does not necessarily result in greater academic achievement. For example, Zhang and Richarde (1999) found that additional student-related variables such as adequate academic preparation, adjustment to instructional styles and the college environment, and ability to prioritize learning are also necessary. The finding that other conative variables are required for academic success suggests that confidence might also be tied to other variables such as epistemological beliefs for optimal learning.

Epistemological Beliefs

Similar to academic confidence research, the area of personal epistemology suggests that conative variables can help or hinder classroom learning and performance. That is, a student's epistemological beliefs about

the nature of knowledge and knowledge acquisition are strongly connected to one's academic achievement (Schommer, 1994). Four epistemological beliefs identified through research are: (1) a belief about the *ability to learn* (ranging from innate to acquired ability), (2) a belief about the *structure of knowledge* (ranging from simple, isolated facts to complex, integrated whole), (3) a belief about the *speed of learning* (ranging from quick to gradual learning), and (4) a belief about the *stability of knowledge* (ranging from static to dynamic knowledge) (Schommer-Aikins, 2002). Epistemological beliefs can be domain-specific or domain-general (Duell & Schommer-Aikins, 2001; Hofer, 2006; Muis, Bendixen, & Haerle, 2006).

Educational researchers (Davis, 1997; Hofer & Pintrich, 1997; Lonka & Lindblom-Ylänne, 1996) claimed that epistemological beliefs play an important role in academically-related behaviours. In particular, such beliefs are viewed as influencing the use of study techniques (Hofer & Pintrich, 1997). For example, students who believe that the structure/content of knowledge consists of unrelated pieces of information may use memorization as a study technique instead of a "deeper" process such as elaboration or integration. It was found that students who viewed science as stable and unchanging tended to memorize scientific facts; in contrast, students who viewed science as dynamic attempted to understand the information (Davis, 1997). Moreover, students who believed that understanding was the best learning strategy performed better on a final exam compared to students who believed memorization was the best technique (Davis, 1997). Individuals who believed in quick, all-or-none learning also used less effective problem-solving strategies in mathematics (Schoenfeld, 1983).

Another study examining the epistemological beliefs and learning approaches of university students found that students who viewed knowledge as a set of absolute truths in medicine were more likely to characterize learning as a passive intake of information compared to students who had a

constructivist idea of knowledge in psychology (Lonka & Lindblom-Ylänne, 1996). The adoption of mastery- versus performance- oriented goals is also related to epistemological beliefs (Braten & Stromso, 2004, 2006). Braten and Stromso found that university students who believed that learning occurs quickly were less likely to possess mastery objectives; similarly, university students who believed that knowledge is stable and transmitted through authority had less mastery-oriented goals. Hence, understanding the role of epistemological beliefs is necessary for helping students to use effective learning strategies and to achieve their academic goals.

Epistemological beliefs are tied to academically-related perceptions at the middle school level (Klacyznski, 2000; Schommer-Aikins, Duell, & Hutter, 2005). For example, middle school students who believed that the ability to learn is innate, and that learning occurs quickly underestimated the effort needed to successfully problem-solve in mathematics, and for understanding the usefulness of this domain (Schommer-Aikins et al., 2005). It was also found that middle school students who held a belief in the uncertainty of knowledge, the importance of scrutinizing their personal beliefs, and the need for logical data analysis were able to subordinate their initial opinions concerning social issues in order to evaluate information objectively (Klaczynski, 2000). Moreover, these students were able to reduce reasoning biases and prevent their personal opinions from becoming polarized (Klacyznski, 2000). These studies suggest that students who developed more sophisticated epistemological beliefs tend to have perceptions that are more amicable to learning and critical/logical thinking than students who possess more naive beliefs.

At the high school level, epistemological beliefs are also related to educational attitudes, performance, and grades. High school students who believed that the ability to learn is innate were more likely to undervalue education (Schommer & Walker, 1997). The less high school students believed in quick learning, the higher academic scores they earned (Schommer, Calvert,

Gariglietti, & Bajaj, 1997). After controlling for measured intelligence, the strongest predictor of grade point average (GPA) by high school students was the belief that learning occurs slowly or quickly; in other words, a higher GPA score was tied to a stronger belief that learning happens gradually (Schommer, 1993).

At the university level, it was found that students who believed in simple knowledge structures had more difficulty understanding mathematics (Schoenfeld, 1983), scientific concepts (Songer & Linn, 1991), and foreign languages (Horwitz, 1988). The belief that knowledge is either right or wrong by university students was tied to poorer monitoring of one's comprehension (Ryan, 1984). University students who were less likely to believe in simple knowledge structures performed better on a statistical comprehension task, which involved a large amount of integration; furthermore, these students were more accurate at assessing their comprehension level of the statistical text (Schommer, Crouse, & Rhodes, 1992). Similarly, a belief in quick learning predicted lower text comprehension by university students; in addition, "quick learning" beliefs were tied to overestimating performance on the comprehension task by the students (Schommer, 1990). A firmer belief in simple and certain (stable) knowledge structures related to poorer performance on ill-defined tasks by university students (Schraw, Dunkle, & Bendixen, 1995). Altogether, these research findings point to the importance of epistemological beliefs—particularly, beliefs about the structure of knowledge (information as simple/discrete versus complex/integrated) and how quickly learning should occur (gradual versus quick)—for university students.

Personal epistemology, like academic confidence, has not been examined for how it relates to intelligence (IQ). However, two recent studies (Trautwein & Lüdtke, 2006; Weinstock, Neuman, & Glassner, 2006) suggested that epistemological beliefs influence cognitive performance even when IQ level is held constant. Trautwein and Lüdtke (2006) found that a belief that

knowledge is certain correlated significantly and negatively with IQ and final school grade; furthermore, students high on certainty beliefs showed lower academic achievement even when controlling for IQ. Weinstock, Neuman, and Glassner (2006) also found a significant difference in IQ among students with different epistemological levels. Specifically, students with an evaluativistic view of knowledge (the belief that knowledge consists of subjective and objective aspects that can be evaluated and integrated) and learning demonstrated higher IQs than students with an absolutistic view of knowledge (the belief that knowledge is objective and absolute); in turn, students with a multiplistic view (the belief that knowledge is subjective and relative) had similar IQs to those who were evaluativistic. These epistemological beliefs accounted for the ability to identify informal reasoning fallacies even when controlling for IQ. Hence, there is evidence to suggest that, in addition to IQ, conative aptitudes such as epistemological beliefs can inform how individuals will perform on cognitive tasks.

While two studies (Schommer, 1990; Schommer-Aikins, Duell, & Hutter, 2005) suggest a relationship between academic confidence and epistemological beliefs, there has yet to be a study which examines how these conative variables together predict academic performance. Therefore, the purpose of the current study was to observe whether the relationship between confidence and epistemological beliefs affect learning and performance within the formal logic (syllogistic reasoning) domain, as they do in other academic disciplines. Confidence may govern the extent to which epistemological beliefs influence syllogistic reasoning performance or alternatively, epistemological beliefs may determine how confidence influences syllogistic reasoning.

In order to investigate the effect of academic confidence and epistemological beliefs on syllogistic reasoning performance, "moderation" and "mediation" pathway analyses were conducted. According to Baron and Kenny (1996), a "moderator" significantly increases the predictor variable's

influence on a criterion variable while a "mediator" allows for a predictor variable to influence the criterion variable. Hence, our goal was to pinpoint whether academic confidence and epistemological beliefs acts as moderators or mediators in explanatory models of syllogistic reasoning performance.

Since relevant literature does not provide information as to how confidence and epistemological beliefs may work together to affect formal logic reasoning, four possible relationships between these two variables were investigated in the present study. By focusing on confidence and epistemological beliefs as potential variables that predict how university students perform on syllogistic tasks, we attempt to identify the possible temporal ordering of these conative variables in formal logic reasoning. In turn, we hoped that our findings could not only be used to improve instruction in formal logic courses for university students but also the ways in which academic performance is understood.

Methods

In this section, we describe: (a) the participants, (b) the study booklet containing the syllogistic reasoning task and epistemological questionnaire, and (c) administrative procedures for the study booklet.

Participants

Seventy-one students (37 males; 33 females; 1 unidentified) were recruited to participate from a first-year course in formal logic at a large research-intensive university in Canada. The mean age of students was 21.7 years with a range of 18 to 37 years. For potential correlational analysis, we also collected data regarding the number of mathematics, computer, and formal logic courses taken by the students, and their expected grade for the course; however, these were not included in the final analyses. At the end of the study, students received $20 for their participation.

Materials and Procedures

A study booklet containing (a) a syllogistic reasoning task, and (b) an epistemological questionnaire was administered to the participants.

Syllogistic Reasoning Task

For the syllogistic reasoning task, participants were given three types of questions that involved: (a) identifying from a set of five Venn diagrams, the ones that correspond to a given quantified proposition, (b) determining whether a set of two premises has a single representation or multiple representations, and (c) identifying the necessary conclusion of a given syllogism from a list of five potential statements. These questions were used to assess the participants' understanding of categorical syllogisms.

Question set 1 (Venn diagrams). For the first set of questions (adapted from Ceraso & Provitera, 1971), participants were given a quantified statement or proposition (using the words or phrases "all", "some", "some…not", or "not"), and asked to identify potentially five correct representations based on the information presented in the proposition, and not on reality. For instance, one question was "The proposition *All Accountants are Beekeepers* could refer to which of the following relations" followed by five Venn diagrams (see Figure 1).

To obtain full points for this question, a participant had to identify the correct representations by choosing the first and second diagrams and leaving blank the other three. Partial points were given when some of the correct diagrams were chosen and some of the incorrect diagrams were left blank. For example, if a participant chose diagrams one, two, and three then he or she received four points for correctly identifying diagrams one and two, and for leaving blank diagrams four and five; however, a point was deducted for choosing diagram three. Hence, the participant would receive a score of 80% (4 out of 5) for this question. After each question, participants rated how confident they were of their answer using a scale from 0 to 100 (0=no confidence to 100=absolute confidence). Altogether, there were four questions

with Venn diagrams measuring participants' knowledge of quantifier propositions.

Question set 2 (single representation vs. multiple representations). For the second set of questions, participants were given two premises, for example "Some Actors are Bankers, No Bankers are Consultants", and asked whether it supports a single possible representation or multiple possible representations. Participants then rated how confident they were of their response (scale from 0 to 100). These questions were scored dichotomously; that is, participants received a one for the correct answer or zero for the incorrect answer. Altogether, there were four questions in this format.

Question set 3 (necessary conclusion of a syllogism). The third set of questions (adapted from Johnson-Laird & Bara, 1984) involved selecting a necessary conclusion in response to a syllogism. For example, the participant would select a conclusion for "Some Actors are Bankers, No Bankers are Consultants" from the following statement options:

a. No Actors are Consultants
b. There is no necessary conclusion
c. All Actors are Consultants
d. Some Actors are Consultants
e. Some Actors are not Consultants

After selecting a conclusion, participants gave a confidence rating for their response on a scale from 0 to 100. These questions were also scored dichotomously. Altogether, there were three questions of this format. Presentation of the set of syllogistic reasoning tasks and epistemological questionnaire (described next) was counterbalanced to avoid an effect due to ordering.

Epistemological Questionnaire

The epistemological questionnaire for undergraduate students was designed to assess knowledge-related beliefs and learning preferences at the

postsecondary level (Schommer, 1998). This questionnaire consists of sixty-three items which are phrased such that higher scores denote less sophisticated epistemological beliefs. Items with positive valences (28 items) reflect more naïve beliefs while items with negative valences (35 items) reflect less naïve beliefs about knowledge. Scores on items with negative valences were later coded so that all sixty-three scores had positive valences. Students used a 5-point rating scale (1=strongly disagree to 5=strongly agree) to choose how much they agreed/disagreed with a particular item.

According to Schommer (1998) who designed the questionnaire, each item belongs to one of 12 subsets, which were later used as variables in a factor analysis (see Table 1). As an example, the subset "AVOID INTEGRATION" includes the items "You will get confused if you try to integrate new ideas from a textbook with knowledge you already have about a topic" (positive valence) and "A really good way to understand a textbook is to re-organize the information according to your own personal scheme" (negative valence). Similarly, the subset "SEEK SINGLE ANSWERS" contains the items "Most words have one clear meaning" (positive valence) and "You never know what a book means unless you know the intent of the author" (negative valence).

Data collection and analysis. At the beginning of the 2006 academic year, the investigators invited students, enrolled in the undergraduate logic course, to participate in the study at the end of the term. During the final examination period, students were given a consent form and the study booklet, along with the final examination booklet. Students who were interested in participating filled out the study booklet after the exam, and returned it to the investigators along with the signed consent form. The investigators remained in the lecture room to answer any study-related questions.

After data collection, we analyzed the results of the epistemological questionnaire to determine whether our sample produced the same four beliefs obtained in Schommer's (Schommer, 1990; Schommer et al., 1992) research with

undergraduate students. We then conducted moderation and mediation analyses (Baron & Kenny, 1996) of (a) students' epistemological beliefs, (b) their level of confidence on the syllogistic reasoning task, and (c) their syllogistic reasoning performance. As stated earlier, because of the lack of research on the interrelationship between academic confidence and epistemological beliefs, we were unable to rely on past research to determine which variable should be designated as predictor, moderator, or mediator. Hence, we conducted a set of analyses in which academic confidence and epistemological beliefs were cast as moderators and mediators in explanatory models of syllogistic reasoning performance.

First, we analyzed academic confidence as the predictor variable for performance on the syllogistic reasoning tasks with epistemological beliefs as the moderator variable. Second, we maintained academic confidence as the predictor variable but designated epistemological beliefs as the mediator variable. Third, we repeated the first analysis but assigned epistemological beliefs as the predictor for syllogistic reasoning performance and confidence as the moderator. Finally, we maintained epistemological beliefs as the predictor but designated confidence as the mediator.

Results

In this section, we describe the factor analysis for the epistemological beliefs, and the moderation and mediation analyses for the three variables of interest.

Factor Analysis of the Epistemological Beliefs

According to Schommer's (Schommer, 1990; Schommer et al., 1992) research with undergraduate students, the sixty-three items, which fall into twelve subsets, load onto four factors describing the extent to which students believe in (a) certain knowledge, (b) simple knowledge structure, (c) fixed ability, and (d) quick learning. In line with Schommer's research, we used a factor analysis (i.e., principal component analysis with orthogonal varimax

rotation) to investigate the pattern of epistemological beliefs by our undergraduate sample.

In the current study, we obtained four factors or constructs of epistemological beliefs similar to those outlined in Schommer's research with some variation. Such variation is not uncommon in empirical studies on epistemological beliefs. For example, in one study (Schommer, 1990), the items under the subset "ABILITY TO LEARN IS INNATE" loaded onto the factor for fixed ability while in another study (Schommer et al., 1992) they loaded onto the factor for quick learning. Similarly, the items under the subset "DON'T CRITICIZE AUTHORITY" loaded onto the factor for simple knowledge in one study (Schommer, 1990) but loaded onto the factor for certain knowledge in another study (Schommer et al., 1992). Hence, some variation may occur depending on the participant sample. Table 2 shows how the subset dimensions loaded onto the four factors or epistemological beliefs.

Because there was some variation between Schommer's and our current sample, we used the epistemological beliefs from our data to investigate how they may relate to academic confidence and performance on the syllogistic reasoning task. By doing this, we wanted to maintain the psychological structure of our sample's epistemological beliefs. To reiterate, the results of our study were obtained by first analyzing academic confidence as the predictor variable with epistemological beliefs as the moderator and mediator. We then analyzed the same data using epistemological beliefs as the predictor with academic confidence as the moderator and mediator. For each analysis, performance on the syllogistic reasoning task was the criterion variable.

Treating Academic Confidence as the Predictor

Our first set of model analyses designated confidence as the predictor with epistemological beliefs as a moderator then as a mediator.

Epistemological beliefs as moderators. To determine whether confidence is a potential predictor of syllogistic reasoning performance, first we conducted

correlational analyses between each confidence measure and its corresponding syllogistic reasoning measure (Barry & Kenny, 1986). As shown in Table 3, the confidence measure for the second set of questions was positively related to the performance measure for this question set (r=.32, p<.01) while the confidence measure for the third set of questions was positively related to its corresponding performance measure (r=.39, p<.01). The confidence measure for the first set of questions was unrelated to its performance measure (r=.20, p>.05).

As a reminder, the second set of questions required students to identify whether two premises result in a single possible representation or multiple possible representations while the third set of questions involved selecting the necessary conclusion for the two premises from a list of five possible alternatives. Finally, the first set of questions required students to identify Venn diagrams, in a set of five representations, corresponding to a quantified premise. Because neither moderation nor mediation can be present in the absence of a significant correlation between the predictor and criterion, further analyses were limited to the second and third set of questions of the syllogistic reasoning task.

According to Barry and Kenny (1986), moderation is indicated when the interaction between a predictor variable and a potential moderator can be shown to significantly increase the predicted variance of the criterion variable. To check if epistemological beliefs are moderating the relationship between confidence and performance on identifying a single representation or multiple representations for a set of premises, hierarchical linear regression was conducted. In the first step of the regression, performance on identifying single or multiple representations was regressed onto confidence and epistemological beliefs. This served to control for the predictor (confidence) and moderator (epistemological beliefs). In the second step, single versus multiple representation performance was regressed onto the interaction term (confidence x epistemological beliefs). If the change in R^2 is significant from the

first step to the second, the interaction term is predicting a significant amount of the variance in single versus multiple representation performance and moderation can be said to exist (Barry & Kenny, 1986).

A hierarchical regression analysis was conducted for each factor of epistemological belief (i.e., certain knowledge, simple knowledge, fixed ability, and quick learning) to determine whether any of the epistemological beliefs functioned as a moderator. Table 4 shows that a significant change in R^2 was not found for any of the beliefs. According to these results, none of the interaction terms for each of the epistemological beliefs led to a significant change in R^2. Therefore, it appears that none of the epistemological beliefs moderates the relationship between confidence and single versus multiple representation performance.

In order to check if the four epistemological beliefs are moderating the relationship between confidence and performance on selecting the necessary conclusion for a set of premises, the same hierarchical regression analysis described previously was performed with performance on selecting the necessary conclusion functioning as the criterion. Table 5 shows that one type of belief led to a change in R^2.

According to these results, it appears that a belief that knowledge is certain moderates the relationship between confidence and performance on selecting the necessary conclusion. Figure 2 illustrates the moderation model that can be constructed based on the above analyses.

Next we conducted a mediation analysis of epistemological beliefs for the relationship between confidence as the predictor and performance on selecting the necessary conclusion for a set of two premises.

Epistemological beliefs as mediators. To reiterate, moderation refers to an *interaction* effect between two variables while mediation suggests that in the absence of the mediator, the criterion outcome would not occur (Frazier, Tix, & Barron, 2004).

The first requirement to perform meditational analysis is to identify two predictor variables that predict a common criterion variable. In this study the two predictor variables of interest were confidence and epistemological beliefs. As was shown in Table 3, confidence is related to performance on selecting the necessary conclusion (r=.39, p<.01). If epistemological beliefs are mediating this relationship, one of the four types of beliefs should correlate with selecting the necessary conclusion performance. Table 6 shows the correlations between epistemological beliefs and this syllogistic reasoning performance.

From Table 6, it is apparent that only the belief in simple knowledge significantly correlates with selecting the necessary conclusion performance (r=-.24, p<.05). Therefore, mediation analyses were conducted to determine whether the relationship between confidence and this kind of performance is mediated by the belief that knowledge is simple.

According to Barry and Kenny (1986), statistical analysis for a continuous predictor variable and a continuous mediator involves three regression equations:

1. regress the mediator onto the predictor;
2. regress the criterion onto the predictor; and
3. regress the criterion onto both the mediator and the predictor.

To confirm mediation, the predictor must be related to the mediator in equation 1, the predictor must be related to the criterion in equation 2, and the mediator must be held to the criterion in equation 3. If these conditions hold, the effect of the predictor on the criterion in the third equation will be less than in equation 2. Finally, although meeting the previously listed conditions results in a lower effect of the predictor on the criterion, this effect must go from being significant to being non-significant in order for complete mediation to be present. If the effect of the predictor on the criterion remains significant after accounting for the mediator, only partial mediation is said to exist. Table 7 shows the results

from checking whether the belief that knowledge is simple meets the requirements for mediation as defined by Barry and Kenny (1986).

Table 7 shows that all of the conditions for mediation have been met but complete mediation has not been found; that is, while the effect of confidence (as predictor) and the belief that knowledge is simple (as mediator) is lower in step 3 (r=.35) than in step 2 (r=.39), the relationship between confidence and selecting the necessary conclusion performance is still significant. Figure 3 shows the path model that can be constructed based on these findings.

From Figure 3, it appears that confidence affects selecting the necessary conclusion performance directly and indirectly through the belief that knowledge is simple; however, the mediation effect is only partial between confidence and selecting the necessary conclusion performance when belief that knowledge is simple is placed "inbetween" the predictor and criterion variables. We now look at the results for having epistemological beliefs as the predictor and confidence as the moderator or mediator for logic performance.

Treating Epistemological Beliefs as the Predictor

In this set of analyses, confidence is investigated as a possible moderator or mediator for the relationship between epistemological beliefs and logic performance. Table 8 shows the correlations between each type of epistemological belief and performance measure of the logic task.

From Table 8 it is clear that only the belief in simple knowledge relates to performance on the questions requiring the identification of Venn diagrams for a given quantified premise, and the identification of the necessary conclusion for two premises of the logic task. Because neither moderation nor mediation can be present in the absence of a main predictor effect, further analyses is limited to the set of questions which required our participants to identify the Venn diagrams, and necessary conclusion.

Confidence as a moderator. To check whether confidence is moderating the relationship between the belief in simple knowledge and logic performance,

hierarchical linear regression was performed. In the first step, logic performance is regressed onto epistemological beliefs and confidence. In the second step, logic performance is regressed onto the interaction term (confidence x epistemological beliefs). If the change in R^2 is significant from the first step to the second, the interaction term can be said to predict a significant amount of the variance in logic performance and moderation is shown to exist. Table 9 shows the change in R^2 after checking whether confidence moderates the relationship between epistemological beliefs, and performance on identifying the Venn diagrams, and the necessary conclusion.

According to these results, none of the interaction terms for each of the confidence measures led to a significant change in R^2. Therefore, it appears that confidence does not moderate the relationship between the belief in simple knowledge, and identifying the Venn diagrams or the necessary conclusion performance. Next, we looked at confidence as a potential mediator between simple knowledge beliefs and identifying the Venn diagrams, and necessary conclusion performance.

Confidence as a mediator. As demonstrated previously, the first requirement for conducting meditational analysis is to identify two predictors that predict the same criterion. In this study, the two predictors are confidence and epistemological beliefs. As was shown in Table 8, the belief in simple knowledge correlated significantly with performance on identifying the Venn diagrams and the necessary conclusion (r=-.420, p<.01, and r=-.237, p<.05, respectively). If confidence is mediating these relationships, the correlation between confidence and performance for each set of questions should be significant. As was shown in Table 1 above, confidence did not predict performance on identifying Venn diagrams (r=.204, p>.05) while confidence did predict performance selecting the necessary conclusion (r=.389, p<.01). Therefore, mediation analysis can be done to investigate whether confidence mediates the relationship between the belief in simple knowledge and the

ability to select the necessary conclusion that logically follows from two premises for a given categorical syllogism.

As was the case in the previous set of analyses, when confidence acted as the predictor, in order to confirm mediation, the predictor must predict the mediator (equation 1 in step 1), the predictor must affect the criterion (equation 2 in step 2) and the mediator must affect the criterion (equation 3 in step 3). If these conditions hold and the correlational value of the third equation is non-significant, then mediation is confirmed. Table 8 shows the results from analyzing whether confidence meets the requirements for mediation as set out by Barry and Kenny (1986).

Table 10 shows that all of the conditions for mediation have been met and complete mediation was found. Figure 4 shows the path model that can be constructed based on these findings.

From Figure 4, it is clear that the belief that knowledge is simple affects performance on selecting the necessary conclusion only indirectly through confidence. Hence, confidence is a mediator of the relationship between epistemological beliefs (i.e., simple knowledge) and selecting the necessary conclusion performance.

Discussion

The need for further investigation into the unique conative aptitudes that students bring to the formal logic domain led us to examine the potential effects of academic confidence and epistemological beliefs on categorical syllogistic reasoning. Through moderation and mediation analyses, we found that these aspects do influence syllogistic reasoning but in different ways.

Two path models depict how confidence and epistemological beliefs together influence syllogistic reasoning: (1) belief in certain knowledge moderates the relationship between confidence and reasoning, and (2) confidence mediates the relationship between belief in simple knowledge and reasoning. Moderation analyses uncover an interaction between two variables

which predicts a criterion outcome. In the current study, we found that students with higher confidence levels and more sophisticated certainty beliefs predict greater reasoning scores. Students with lower confidence levels and more naïve certainty beliefs predict poorer reasoning scores. Finally, individuals with higher confidence levels and more naïve certainty beliefs, and individuals with lower confidence levels and more sophisticated certainty beliefs predict intermediate reasoning scores.

Mediation analyses uncover a mechanism (mediator variable) through which a predictor variable causes a criterion outcome. For the present study, we found that confidence significantly mediates between a belief in simple knowledge and logic performance. Students who believe less in simple knowledge perform better on the logic task due to their higher level of confidence or self-efficacy beliefs. Similarly, students who believe more in simple knowledge perform worse on the logic task due to lower level of confidence.

For both the moderation and mediation models, confidence and epistemological beliefs only affected performance on questions involving the selection of necessary conclusions. These questions were the most difficult since students had to understand the relationship between two quantified premises in order to derive the necessary conclusion. In other words, for this set of questions, students were actually performing categorical syllogistic reasoning. In contrast, questions with Venn diagrams were the least difficult since participants were required to understand one quantified premise (e.g., "All Accountants are Beekeepers"). Questions involving single versus multiple representations were intermediate in difficulty since participants needed to identify whether two premises had a single representation or multiple representations. Hence, we found that conative processes significantly affected performance for the difficult set of questions. In other words, confidence and epistemological beliefs

may be most critical when students are faced with actually solving categorical syllogisms.

The finding that epistemological beliefs of our undergraduate students somewhat varied from those of Schommer's students needs to be addressed. This variation may suggest that the students have different underlying constructs of epistemological beliefs. If we recall that for our sample the belief in certain knowledge consisted of items from the subsets "seek single answers" and "depend on authority", it may be that our students did not have a belief in certain knowledge *per se* but rather a belief in seeking single answers. The belief in simple knowledge by our students, however, may continue to be interpreted as such since the subsets could still be argued to reflect a construct of "simple knowledge" belief (i.e., "avoid integration", "avoid ambiguity", "knowledge is certain", "don't criticize authority", and "learning is quick"). The finding that epistemological beliefs may slightly or significantly differ depending on the sample implies that further research needs to be done on what constitutes "epistemological beliefs" (for example, personal epistemology may differ based on gender, culture).

In general, the results of our study suggest that, as educators, we need to be aware that conative aptitudes (in addition, to cognitive ones) can significantly influence whether students learn and perform optimally within the formal logic domain. While teaching formal logic concepts, rules, and procedures is important, it is also critical to help students develop higher levels of self-confidence and more sophisticated epistemological beliefs. As our study reveals, conative aptitudes become important when students engage in more complex tasks. Through similar kinds of research, we would like to help students do well in their formal logic courses at the university level. Furthermore, we would like to see students utilize their acquired logic skills in their daily lives.

References

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*.

Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning.

Educational Psychologist, 28, 117-148.

Bara, B.G., & Bucciarelli, M. (1995). Development of syllogistic reasoning. *American Journal of*

Psychology, 108(2), 157-193.

Baron, R.M., & Kenny, D.A. (1996). The moderator-mediator variable distinction in social

psychology research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 31(6), 1173-1182.

Blanchette, I., & Richards, A. (2004). Reasoning about emotional and neutral materials: Is logic

affected by emotion? *Psychological Science*, 15(11), 745-752.

Braten, I., & Stromo, H.I. (2004). Epistemological beliefs and implicit theories of intelligence as

predictors of achievement goals, *Contemporary Educational Psychology*, 29, 371-388.

Braten, I., & Stromo, H.I. (2006). Predicting achievement goals in two different academic

contexts: A longitudinal study. *Scandinavian Journal of Educational Research*, 50(2), 127-148.

Britner, S., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school

students. *Journal of Research in Science Teaching*, 43(5), 485–499.

Butler, D.L., & Winne, P.H. (1995). Feedback and self-regulated learning: A theoretical synthesis.

Review of Educational Research, 65(3), 245-281.

Ceraso, J., & Provitera, A. (1971). Sources of error in syllogistic reasoning. *Cognitive Psychology*,

2, 400-410.

Chater, N., & Oaksford, M. (1999). The probability heuristics model of syllogistic reasoning.

Cognitive Psychology, 38, 191–258.

Davis, E.A. (1997, April). *Students' Epistemological Beliefs about Science and Learning*. Paper

presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Duell, O.K., & Schommer-Aikins, M. (2001). Measures of people's beliefs about knowledge and

learning. *Educational Psychology Review*, 13(4), 419-449.

Lau, S., & Roeser, R.W. (2002). Cognitive abilities and motivational processes in high school

students' situational engagement and achievement in science.

Educational Assessment, 8(2), 139-162.

St. B.T. Evans, J. (2003). In two minds: Dual-process accounts of reasoning. *Trends in Cognitive*

Sciences, (7)10, 245-259.

Frazier, P.A., Tix, A.P., & Barron, K.E. (2004). Testing moderator and mediator effects in

counseling psychology research. *Journal of Counseling Psychology*, 51(1), 115-134.

Gagnè, F., & St. Père, F. (2001). When IQ is controlled, does motivation still predict

achievement? *Intelligence*, 30, 71-100.

Halpern, D.F. (1997). *Critical Thinking Across the Curriculum: A Brief Education of Thought and*

Language. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Hofer, B.K. (2006). Beliefs about knowledge and knowing: Integrating domain specificity and

domain generality: A response to Muis, Bendixen, and Haerle (2006). *Educational Psychology Review*, 18(1), 67-76.

Hofer, B.K., & Pintrich, P.R. (1997). The development of epistemological theories: Beliefs about

knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88-140.

Horwitz, E. (1988). The beliefs about language learning of beginning university foreign language

students. *Modern Language Journal*, 72, 283-294.

Jensen, A.R. (1998). *The G Factor: The Science of Mental Ability*. Westport, CT: Praeger.

Johnson-Laird, P.N. (1983). *Mental Models: Towards a Cognitive Science of Language, Inference,*

and Consciousness. Cambridge, Massachusetts: Harvard University Press.

Johnson-Laird, P.N., & Bara, B.G. (1984). Syllogistic inference. *Cognition*, 16, 1-61

Kirby, G.R., & Goodpaster, J.R. (2007). *Thinking: An Interdisciplinary Approach to Critical and*

Creative Thought (Fourth Edition). Upper Saddle River, NJ: Pearson/Prentice Hall.

Klaczynski, P.A. (2000). Motivated scientific reasoning biases, epistemological beliefs, and

theory of polarization: A two-process approach to adolescent cognition. *Child Development*, 71(5), 1347-1366.

Kupermintz, H. (2002). Affective and conative factors as aptitude resources in high school
science achievement, *Educational Assessment*, 8(2), 123-137.
Lawson, A.E., Banks, D.L., Logvin, M. (2007). Self-efficacy, reasoning ability, and achievement in
college biology. *Journal of Research in Science Teaching*, 44(5), 706–724.
Leighton, J.P. (2006). Teaching and assessing deductive reasoning skills. *Journal of Experimental*
Education, 74(2), 109-136.
Lonka, K., & Lindblom-Ylänne, S. (1996). Epistemologies, conceptions of learning, and study
practices in medicine and psychology. *Higher Education*, 31(1), 5-24.
Madewell, J., & Shaughnessy, M.F. (2003). An interview with Frank Pajares. *Educational*
Psychology Review, 15(4), 375-397.
Martin, A.J., & Marsh, H.W. (2006). Academic resilience and its psychological and educational
correlates: A construct validity approach. *Psychology in the Schools*, 43(3), 267-281.
Muis, K.R., Bendixen, L.D., & Haerle, F.C. (2006). Domain-generality and domain-specificity in
personal epistemology research: Philosophical and empirical reflections in the development of a theoretical framework. *Educational Psychology Review*, 18, 3-51.
Multon, K.D., Brown, S.D., & Lent, R.W. (1991). Relation of self-efficacy beliefs to academic
outcomes: A meta-analytic investigation. *Journal of Counseling Psychology*, 38(1), 30-38.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research*, 66(4), 543-578.

Pajares, F. (2000). Frank Pajares on nurturing academic confidence. *Emory Report*, 52(21). Retrieved June 28, 2007 from http://www.des.emory.edu/mfp/NurturingAcademicConfidence.html.

Pajares, F., & Johnson, M.J. (1993, April). *Confidence and Competence in Writing: The Role of Self-efficacy, Outcome Expectancy, and Apprehension*. Paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, GA.

Pintrich, P.R., & De Groot, E.V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, 82, 33–40.

Rips, L.J. (1994). *The Psychology of Proof: Deductive Reasoning in Human Thinking*. Cambridge, Massachusetts: MIT Press.

Ryan, M.P. (1984). Monitoring text comprehension: Individual differences in epistemological standards. *Journal of Educational Psychology*, 76, 248-258.

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

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82(3), 498-504.

Schommer, M. (1993). Epistemological development and academic performance among
secondary students. *Journal of Educational Psychology*, 85(3), 406-411.
Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings
and provocative confusions. *Educational Psychology Review*, 6(4), 293-319.
Schommer, M. (1998). The influence of age and education on epistemological beliefs. *British*
Journal of Educational Psychology, 68(4), 551-560.
Schommer-Aikins, M. (2002). An evolving theoretical framework for an epistemological belief
system. In B.K. Hofer & P.R. Pintrich (Eds.), *Personal Epistemology: The Psychology of Beliefs About Knowledge and Knowing* (pp. 103-118). Mahwah, New Jersey: Lawrence Erlbaum
Associates, Publishers.
Schommer-Aikins, M., Duell, O.K., & Hutter, R. (2005). Epistemological beliefs, mathematical
problem-solving beliefs, and academic performance of middle school students. *The Elementary School Journal*, 105(3), 289-304.
Schommer, M., Calvert, C., Gariglietti, G., & Bajaj, A. (1997). The development of epistemological beliefs among secondary students: A longitudinal study. *Journal of Educational Psychology*, 89(1), 37-40.
Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text
comprehension: Believing it's simple doesn't make it so. *Journal of Educational Psychology*, 84(4), 435-443.
Schommer, M., & Walker, K. (1997). Epistemological beliefs and valuing school: Considerations

for college admissions and retention. *Research in Higher Education*, 38, 173-186.

Schraw, G.S., Dunkle, M.E., & Bendixen, L.D. (1995). Cognitive processes in well-defined and ill-

defined problem solving. *Applied Cognitive Psychology*, 9, 523-538.

Shavelson, R.J., Roeser, R.W., Kupermintz, H., Lau, S., Ayala, C., Haydel, A., Schultz, S., Gallagher,

L., & Quihuis, G. (2002). Richard E. Snow's remaking of the concept of aptitude and multidimensional test validity: Introduction to the special issue. *Educational Assessment*, 8(2), 77-99.

Skuy, M., & Mentis, M. (1999). Syllogisms. In M. Skuy & M. Mentis (Eds.), *Bridging Learning In*

and Out of the Classroom (pp. 97-104). Thousand Oaks, CA: Sage Publications, Inc.

Smith, S. M., & Levin, I. P. (1996). Need for cognition and choice framing effects. *Journal of*

Behavioral Decision Making, 9, 283–290.

Songer, N.B., & Linn, M.C. (1991). How do students' views of science influence knowledge

integration? *Journal of Research in Science Teaching*, 28, 761-784.

Tavani, C.M., & Losh, S.C. (2003). Motivation, self-confidence, and expectations as predictors of

the academic performances among our high school students. *Child Study Journal*, 33(3), 141-151.

Trautwein, U., & Lüdtke, O. (2006). Epistemological beliefs, school achievement, and college

major: A large-scale longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology*, 32, 348-366.

Weinstock, M.P., Neuman, Y., & Glassner, A. (2006). Identification of informal reasoning

fallacies as a function of epistemological level, grade level, and cognitive ability. *Journal of Educational Psychology*, 89(3), 327-341.

Winne, P.H. (1997). Experimenting to bootstrap self-regulated learning. *Journal of Educational*

Psychology, 89(3), 397-410.

Winne, P.H. (2005). Key issues in modeling and applying research on self-regulated learning,

Applied Psychology: An International Review, 54(2), 232–238.

Zhang, Z., & Richarde, R.S. (1999, April). *Freshman Academic Achievement: A Structural*

Equation Model. Paper presented at the Annual Meeting of the American Educational Research Association, Montreal, Canada.

Zimmerman, B.J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning:

Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology*, 82, 51-59.

Table 1

Factors or Beliefs, Subset Dimensions, and Number of Items (Schommer, 1990)

Factor or belief	Subset dimension (sample item)	Number of items
Certain knowledge	KNOWLEDGE IS CERTAIN ("Truth is unchanging.")	6
Simple knowledge	AVOID INTEGRATION ("You will get confused if you try to integrate new ideas from a textbook with knowledge you already have about a topic.")	8
	AVOID AMBIGUITY ("It is annoying to listen to a lecturer who cannot seem to make up his mind as to what he really believes.")	5
	DON'T CRITICIZE AUTHORITY ("People who challenge authority are over-confident.")	6
	DEPEND ON AUTHORITY ("Whenever I encounter a difficult problem in life, I consult with my parents.")	4
	SEEK SINGLE ANSWERS ("Most words have one clear meaning.")	11
Fixed ability	ABILITY TO LEARN IS INNATE ("The ability to learn is innate.")	4
	SUCCESS IS UNRELATED TO HARD WORK ("The really smart students don't have to work hard to do well in school.")	4
	LEARN THE FIRST TIME ("Almost all the information you can learn from a textbook you will get during the first reading.")	3
	CAN'T LEARN HOW TO LEARN ("Self-help books are not much help.")	5
	CONCENTRATED EFFORT IS A WASTE OF TIME ("If a person tries too hard to understand a problem, they will most likely end up being confused.")	2
Quick Learning	LEARNING IS QUICK ("If you are ever going to understand something, it will make sense to you the first time you hear	5

it.")

Table 2

Four Factors or Beliefs, Subset Dimensions, and Factor Loadings

Factor or belief	Subset dimension	Factor loading
Certain knowledge	DEPEND ON AUTHORITY	.76
	SEEK SINGLE ANSWERS	.75
Simple knowledge	AVOID INTEGRATION	.69
	AVOID AMBIGUITY	.76
	KNOWLEDGE IS CERTAIN	.43
	DON'T CRITICIZE AUTHORITY	.77
	LEARNING IS QUICK	.61
Fixed ability	ABILITY TO LEARN IS INNATE	.71
	SUCCESS IS UNRELATED TO HARD WORK	.77
Quick learning	LEARN THE FIRST TIME	.66
	CAN'T LEARN HOW TO LEARN	.82
	CONCENTRATED EFFORT IS A WASTE OF TIME	.81

Table 3

Correlations between Confidence and Performance on Venn Diagrams, Single and Multiple Representations, and Necessary Conclusions

Predictor	Criterion	Correlation (*r*)
Confidence on Venn diagrams	Performance on Venn diagrams	.204
Confidence on single and multiple representations	Performance on single and multiple representations	.319**
Confidence on necessary conclusions	Performance on necessary conclusions	.389**

**p<.05, **p<.01*

Table 4

Moderation Analysis of Epistemological Beliefs for the Relationship between Confidence and Performance on Single and Multiple Representations

Moderator	R^2 change
Belief that ability is fixed	.000
Belief that knowledge is simple	.001
Belief that learning is quick	.013
Belief that knowledge is certain	.001

***p<.05, ****p<.01*

Table 5

Moderation Analysis of Epistemological Beliefs for the Relationship between Confidence and Performance on Necessary Conclusions

Moderator	R^2 change
Belief that ability is fixed	.005
Belief that knowledge is simple	.001
Belief that learning is quick	.000
Belief that knowledge is certain	.119**

**p<.05, **p<.01*

Table 6

Correlations between Epistemological Beliefs and Performance on Necessary Conclusions

Mediator	Correlation with performance on necessary conclusions
Belief that ability is fixed	0.169
Belief that knowledge is simple	-0.237*
Belief that learning is quick	0.034
Belief that knowledge is certain	0.103

**p<.05, **p<.01*

Table 7

Standardized Regression Coefficients for Belief that Knowledge is Simple as Mediator between Confidence and Performance on Necessary Conclusions

Mediator	Step 1	Step 2	Step 3
Belief that knowledge is simple	-.352**	.389**	.349**

**p<.05, **p<.01*

Table 8

Correlations between Epistemological Beliefs and Performance on Venn Diagrams, Single and Multiple Representations, and Necessary Conclusions

Predictor	Correlation with performance on Venn diagrams	Correlation with performance on single and multiple representations	Correlation with performance on necessary conclusions
Belief that ability is fixed	-.160	-.169	.169
Belief that knowledge is simple	-.420**	-.075	-.237*
Belief that learning is quick	-.185	-.160	.034
Belief that knowledge is certain	-.052	-.086	.103

**p<.05, **p<.01*

Table 9

Moderation Analysis of Confidence for the Relationship between the Belief in Simple Knowledge, and Performance on Venn Diagrams, and Necessary Conclusions

Moderator	Criterion	R^2 change
Confidence on Venn diagrams	Performance on Venn diagrams	.000
Confidence on necessary conclusions	Performance on necessary conclusions	.001

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

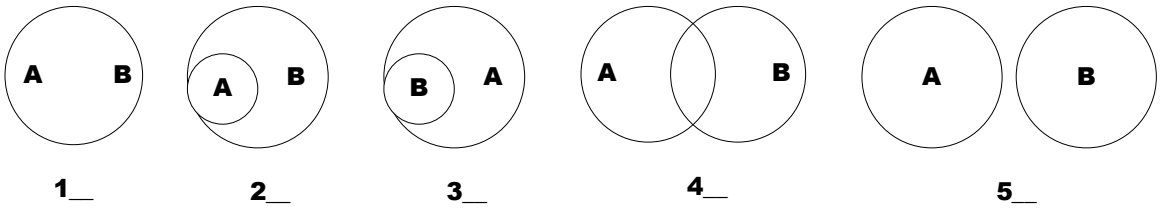
Table 10

Standardized Regression Coefficients for Confidence as a Mediator for the Relationship between Belief in Simple Knowledge and Performance on Necessary Conclusions

Mediator	Step 1	Step 2	Step 3
Confidence on necessary conclusions	-.352**	-.237*	-.114

**p<.05, **p<.01*

Figure 1. Example of question with Venn diagrams.



A = Accountants
B = Beekeepers

Figure 2. Moderation model for the belief that knowledge is certain with academic confidence as the predictor and syllogistic reasoning performance (selecting the necessary conclusion) as the criterion.

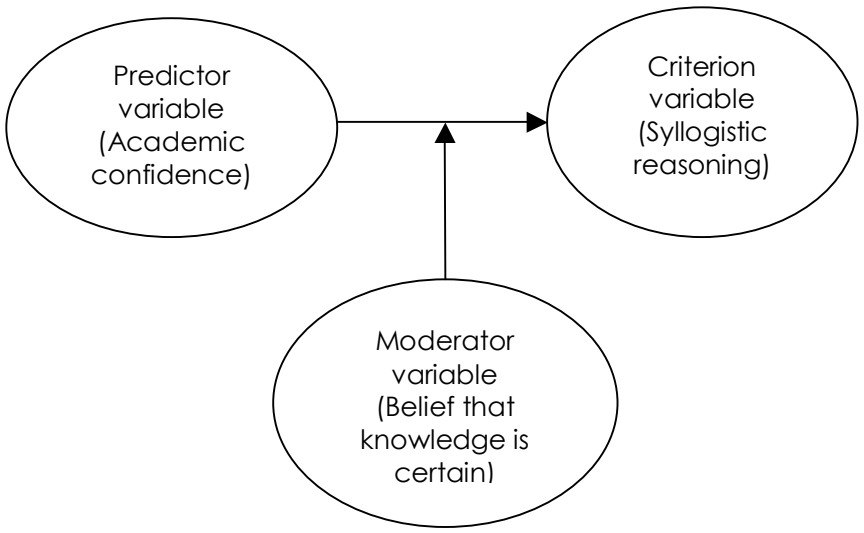


Figure 3. Partial mediation model for belief that knowledge is simple with academic confidence as the predictor and syllogistic reasoning performance (selecting the necessary conclusion) as the criterion.

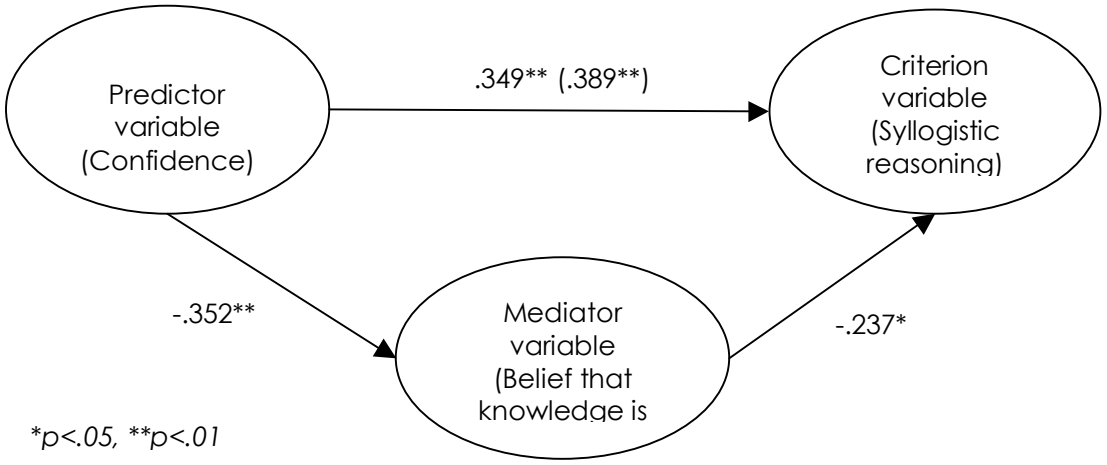


Figure 4. Mediation model for academic confidence with the belief that knowledge is simple as the predictor and syllogistic reasoning performance (selecting the necessary conclusion) as the criterion.