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Testing the TIDE: Examining the Nature of Students’ Epistemic Beliefs Using a Multiple Methods Approach

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The purpose of this study was to empirically scrutinize Muis, Bendixen, and Haerle’s (2006) Theory of Integrated Domains in Epistemology framework. Secondary, college, undergraduate, and graduate students completed self-reports designed to measure their domain-specific and domain-general epistemic beliefs for mathematics, psychology, and general knowledge, respectively. Following completion of the questionnaires, students participated in an interview that further probed their epistemic beliefs to better understand the nature of their beliefs. Results from our study suggest students’ beliefs across domains are somewhat related but still unique to that particular domain. Moreover, analysis of the interviews revealed that students espouse general knowledge beliefs and domain-specific beliefs. Interestingly, students expressed absolutist beliefs about mathematics, but were multiplist in their stances toward psychology and general knowledge. When asked to provide examples that came to mind when reporting their beliefs, students frequently drew on their classroom experiences to explain why they held specific beliefs. We discuss theoretical implications.

**Keywords** epistemic beliefs, domain differences, mixed methods

“EVERYTHING I KNOW, I know from experience” (Hooper, *The King’s Speech*, 2010). Reflected in this quote is one man’s belief about how he came to know all that he knows. Is this the only path through which one may acquire knowledge? Over the past few centuries, philosophers have grappled with questions about how individuals come to know and what counts as knowledge. Indeed, the topic is highly complex (see Murphy, Alexander, & Muis, 2012), one that educational psychologists have also begun to explore over the past 40 years. For educational psychologists, however, questions regarding the nature of knowledge and knowing have focused more on individuals’ conceptions about the nature of knowledge and knowing, or their epistemic beliefs (Hofer & Pintrich, 1997). Like the philosophical literature, theoretical considerations of individuals’ beliefs about knowledge and knowing have greatly varied. As Hofer and Pintrich (1997) noted, this variation has resulted in a number of different research programs that focus on various aspects of individuals’ epistemic beliefs.
In an attempt to unite the various perspectives, and to address how epistemic beliefs may be both domain general and domain specific, Muis, Bendixen, and Haerle (2006) proposed an integrated theoretical framework. Although some studies have been conducted to evaluate their framework, much more work is needed, particularly with regard to whether individuals espouse the various types of beliefs they propose. A better understanding of the types of beliefs students espouse is particularly important with regard to the role that beliefs play in learning in general. For example, as Schraw (2001) noted, a more precise delineation of the kinds of beliefs that students espouse (e.g., domain-specific vs. more general beliefs) may help to clarify research that explores relations between beliefs, motivation, and various facets of learning. As Schraw argued, domain-specific epistemic beliefs may play a predominant role in task-specific facets of learning, whereas more general epistemic beliefs may be more influential of general motivation and academic engagement. To date, research has not fully explored whether students simultaneously espouse these different levels of beliefs (e.g., more general vs. more specific, as proposed in the Muis et al. framework). Additionally, given the difficulty researchers have had in measuring epistemic beliefs via self-reports (see Debacker, Crowson, Beesley, Thoma, & Hestvold, 2010), more clarification is warranted with regard to the nature of students’ espoused beliefs to help inform the development of instruments designed to measure epistemic beliefs.

Accordingly, the purpose of this study was to empirically scrutinize the Muis et al. (2006) integrated theoretical framework to assess whether students espoused beliefs across the different levels of specificity, specifically from more general beliefs to domain specific beliefs. Using an interview protocol, we probed students regarding their beliefs about knowledge and knowing to compare their beliefs across domains and educational experience. Prior to detailing our study, to situate our analyses, we first briefly review the various theoretical frameworks, detail the Muis et al. (2006) framework, and then describe the interviewing technique that we employed to investigate the nature of individuals’ beliefs.

## THE VARIOUS FRAMEWORKS

As Hofer and Pintrich (1997) noted in their seminal review, although various theoretical frameworks have been developed, researchers have differed in their conceptualizations and labeling of epistemic beliefs. Initial research characterized epistemic beliefs as unidimensional and domain general, and hypothesized that they developed in a stage-like fashion (e.g., Belenky, Clinchy, Goldberger, & Tarule, 1986; Kitchener & King, 1981; Kuhn, 1991; Perry, 1970). Empirical investigations within the developmental frameworks have examined how individuals move through different levels of epistemological thought. Five major frameworks have been identified: the “Perry scheme” (Perry, 1970), “women’s ways of knowing” (Belenky et al., 1986), the Epistemological Reflection Model (Baxter Magolda, 2004), reflective judgment (King & Kitchener, 1994), and Kuhn’s (1991) epistemological model that underlies argumentative reasoning (for reviews see Hofer & Pintrich, 1997; and Schommer, 1998). Across the various frameworks, three stages of development have been identified, which range from less constructivist to more constructivist,^1^ a term that has been used to describe beliefs about knowledge as being complex, tentative, personally constructed, and justified through evidence. Constructivist beliefs are distinguished from the broader term, constructivism, which

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^1^Constructivist epistemic beliefs include beliefs about knowledge as being complex, tentative, personally constructed, and justified through evidence. Constructivist beliefs are distinguished from the broader term, constructivism, which
as described in the following: (a) absolutism/objectivism, (b) multiplism/subjectivism, and (c) evaluativism/objectivism–subjectivism.

Individuals at the absolutism stage (less constructivist) view knowledge as right or wrong, believe that knowledge is objective and reflects a true reality, and believe authority figures are the source of knowledge. In contrast to the absolutist stage, individuals who begin to realize there are multiple perspectives that may be in conflict conclude that one perspective is as valid as another and that each perspective is mere opinion. Through higher levels of education, individuals realize there are multiple possibilities for knowledge and that knowledge claims should be evaluated by the evidence presented (most constructivist). At this level, individuals acknowledge that knowledge is correct relative to multiple contexts.

Other theorists have conceptualized epistemic beliefs as a set of beliefs about knowledge and knowing that include multiple dimensions that are more theory-like (Hofer, 2000; Hofer & Pintrich, 1997), or are independent of one another (Schommer, 1990). Although the number and nature of the dimensions differ across the frameworks, there are commonalities that reflect four belief dimensions about knowledge and knowing that vary along a belief continuum from less constructivist to more constructivist (Hofer, 2004). These include (a) the certainty of knowledge, ranging from knowledge is unchanging to knowledge is evolving; (b) the simplicity of knowledge, ranging from knowledge is organized as isolated bits and pieces to knowledge is organized as highly interrelated concepts; (c) the source of knowing, ranging from knowledge is handed down by authority to knowledge is acquired through reason or logic; and (c) the justification of knowledge, which refers to how individuals consider how a proposition or belief becomes justified knowledge via personal experience and one’s own subjective opinion or through systematic inquiry and integration of multiple sources of information. As Hofer (2004) delineated, the first two dimensions reflect individuals’ beliefs about knowledge, whereas the last two dimensions reflect individuals’ beliefs about knowing.

THE TIDE FRAMEWORK

In an attempt to integrate both developmental and multidimensional perspectives, Bendixen and Rule (2004), Greene, Azevedo, and Tourney-Purta (2008), and Muis et al. (2006) proposed new frameworks. Of particular interest for this study, Muis et al. proposed a unified theoretical framework, the Theory of Integrated Domains in Epistemology (TIDE) framework, to describe how the various dimensions develop over time and how they are reciprocally influential. Consistent with Hofer and Pintrich’s (1997) dimensional framework that describes two beliefs about knowledge and two beliefs about knowing, Muis et al. proposed four epistemic belief dimensions that develop over time and with educational experience: certainty of knowledge, simplicity of knowledge, source of knowing, and justification for knowing. Each dimension develops from a less constructivist position, wherein knowledge is viewed as unchanging, unrelated, handed down by authority, and unquestionably accepted as truth without critical consideration of the sources from which knowledge is derived, to a more constructivist position wherein knowledge is viewed as tentative, complexly related, personally constructed, and critically evaluated.

ranges across perspectives from radical constructivism, which reflects an extreme individualistic perspective, to social constructivism, which is informed by Vygotsky’s (1986) work (for an overview see Murphy, Alexander, & Muis, 2012).
Beyond the typical epistemic beliefs that researchers have measured in educational contexts, Muis et al. (2006) further proposed three specific types of beliefs within which the four dimensions develop: general epistemic beliefs, academic epistemic beliefs, and domain-specific epistemic beliefs. Muis et al. describe general epistemic beliefs as beliefs that individuals espouse about the world outside of the academic context (e.g., beliefs about knowledge in everyday life). According to their framework, the commencement of formal education initiates the development of individuals’ academic epistemic beliefs, which are beliefs that students have about knowledge covered in school in particular. Academic beliefs are distinguished from general beliefs by their specific focus on the school context, but at this level of specificity, individuals do not distinguish different domains. Rather, beliefs about knowledge covered in school (academic beliefs) can be distinguished from knowledge in everyday life (general beliefs).

Comparable to general epistemic beliefs, academic epistemic beliefs and domain-specific epistemic beliefs develop primarily during the academic years and continue to evolve over the lifespan. As individuals experience more of each specific domain within the school context (e.g., through course work in mathematics, history, socials), their beliefs about those domains become more fine tuned. Moreover, they theorized that domain-specific epistemic beliefs begin to develop more prominently during the secondary and postsecondary school years, given that courses are domain specific during those years and are influenced primarily by the instructional environment. To align their framework with the developmental models, they further proposed that development occurs along each of the four dimensions, from an absolutist perspective, to a multiplist and, finally, an evaluativist perspective.

Some studies have been conducted to empirically evaluate the Muis et al. (2006) TIDE framework (Muis & Duffy, 2013; Muis & Foy, 2010; Muis, Franco, & Gierus, 2011). For example, although Muis et al. (2006) hypothesized three different levels of epistemic beliefs (e.g., general, academic, and domain-specific), they further hypothesized that an additional level of specificity may be required beyond the domain-specific level, such as topic-specific beliefs, or beliefs about specific knowledge types, like procedural or conceptual knowledge. For example, epistemic beliefs may vary as a function of how knowledge is represented in domains such as mathematics or physics. Mathematics knowledge can be represented numerically, or conceptually via theorems that inform the numerical representations that are expressed procedurally. To test this hypothesis, Muis et al. (2011) examined whether students’ epistemic beliefs about statistics knowledge varied depending on how that knowledge was represented. Students completed Hofer’s (2000) Domain-Focused Epistemological Beliefs Questionnaire five times over the course of a semester. Immediately following an in-class review session for an upcoming procedural test (e.g., calculating a t-test, variance, etc.) or a conceptual test on the same content (“What is variance?”), students reported their beliefs about the specific content they just reviewed. Results revealed that students’ domain-specific beliefs along the four dimensions (certainty, simplicity, source, and justification) differed when the same statistics knowledge was presented conceptually versus procedurally, lending support to the Muis et al. (2006) hypothesis. Much more work is needed, however, to fully chart the various types of epistemic beliefs they propose (Hofer, 2006).

In particular, no empirical work has been conducted to explore whether students espouse general epistemic beliefs (knowledge outside of the school context) and whether there are mean-level differences between these general beliefs and domain specific epistemic beliefs. Although previous studies have explored whether students espouse similar or different beliefs across different domains by assessing mean differences in students’ self-reported beliefs, or by conducting
correlational or factory analytic analyses (e.g., Buehl, Alexander, & Murphy, 2002; Hofer, 2000; Schommer & Walker, 1995; for a complete review see Muis et al., 2006), research is needed to further explore the nature of students’ epistemic beliefs and how they may vary across levels of specificity. As such, it was imperative to use a self-report instrument that paralleled the Muis et al. (2006) framework while at the same time allowing for variations in item stems to measure more general and domain-specific beliefs. Accordingly, we adopted Hofer’s (2000) Discipline-Focused Epistemological Beliefs Questionnaire, given its flexibility in usage across domains. Although developed with these four dimensions in mind, Hofer (2000) found slight dimensional variations based on factor analytic work. Specifically, Hofer’s confirmatory factor analyses revealed a strong overlap between beliefs about certain knowledge and simple knowledge and these were subsequently merged. The justification for knowing and source of knowing were two separate factors, and a new factor, attainability of truth, emerged. As such, we used these four dimensions to explore students’ epistemic beliefs with our sample, beliefs that closely parallel the four dimensions in the Muis et al. (2006) framework. Additionally, given the challenges researchers have faced with regard to relying solely on self-reports of students’ epistemic beliefs (see DeBacker et al., 2010), we felt it imperative to triangulate self-reports with in-depth interviews to provide a richer analysis of students’ espoused beliefs.

We also evaluated the Muis et al. (2006) assumption that students’ beliefs vary as a function of educational experience; that is, with more educational experience, the specificity of students’ beliefs should increase (become more domain-specific) and should be more multiplist or evaluativist, depending on their educational level. To assess whether students espouse general and more domain-specific beliefs, students from secondary, college, undergraduate, and graduate levels of education completed questionnaires that measured their epistemic beliefs about mathematics, psychology, and general knowledge (“everyday knowledge”). Mathematics and psychology were chosen as domains, given that they differ epistemologically (see Muis et al., 2006) and structurally (Biglan, 1973). Structurally, although mathematics is considered a well-structured, hard, and pure domain, psychology is considered an ill-structured, soft, and applied domain (see Biglan, 1973). Finally, researchers have found that students at all levels of education espouse less constructivist beliefs about mathematics despite their exposure to this domain, whereas students typically espouse more constructivist beliefs about psychology even with little exposure (see Muis, 2004). Accordingly, we felt these two highly contrasting domains would provide a unique context within which to explore our research questions. We detail our study next.

THE CURRENT STUDY

Secondary, college, undergraduate-level, and graduate-level students were interviewed to assess their beliefs about knowledge and knowing across three domains: mathematics, psychology, and general knowledge. Additionally, we probed students regarding the nature of their epistemic beliefs for these two domains and their beliefs about general knowledge to assess expressed similarities and differences in their beliefs, and to explore whether they were absolutists, multiplist,
or evaluativists across the multiple dimensions in the Muis et al. (2006) framework. Our research questions were as follows:

1. Do students self-report mean-level differences in general beliefs and domain-specific epistemic beliefs?
2. To what extent are general beliefs and domain-specific beliefs related?
3. What is the nature of students’ expressed epistemic beliefs across educational levels and as a function of domain?

For the first question, based on the Muis et al. (2006) framework, using a repeated-measures analysis, we hypothesized that students would report mean-level differences in their general epistemic beliefs compared to their more domain specific beliefs, and that students would espouse less constructivist beliefs about mathematics than general knowledge and knowledge in psychology (Muis, 2004). For the second question, based on previous research (e.g., Hofer, 2000; Schommer & Walker, 1995), we hypothesized moderate correlations between each of the same dimensions across each domain. Finally, given the qualitative nature of the analyses for the interviews, we did not develop specific hypotheses with regard to the nature of students’ expressed beliefs.

METHODOLOGY

Participants

Thirty-four students (n = 24 females) from four levels of education within various educational institutes volunteered to participate. Ten participants were secondary school students (n = 5 females, age range 15–16 years of age), seven were postsecondary collegiate students (n = 5 females, age range 17–18), nine were undergraduate students (n = 7 females, age range 19–21), and eight were graduate students (n = 7 females, age range 23–30). With the exception of the secondary school students (given that they do not declare majors at that level of education), students were sampled primarily from social sciences disciplines.

Materials

Participants completed three versions of the Discipline-Focused Epistemological Beliefs Questionnaire (DFEBQ; Hofer, 2000) adapted for two domains: psychology, and mathematics. Items were also slightly modified for general knowledge. Items on the scale were developed to reflect the four belief dimensions that Hofer and Pintrich (1997) identified in their theoretical framework: certainty of knowledge (e.g., “Truth is unchanging in this subject”), simplicity of knowledge (e.g., “Ideas in this subject are really complex” reverse coded), source of knowing (e.g., “If my personal experience conflicts with ideas in the textbook, the book is probably right”), and justification for knowing (e.g., “First-hand experience is the best way of knowing something in this field”). See Table 1 for Cronbach alpha reliability estimates.

3Although the DFEBQ was not developed for domain-general assessments, it was originally developed from instruments that were domain general (e.g., Schommer’s [1990] questionnaire). As such, slight modifications made the DFEBQ...
TABLE 1
Means and Standard Deviations for Each Dimension for Beliefs About General Knowledge, Mathematics, and Psychology

<table>
<thead>
<tr>
<th></th>
<th>General</th>
<th>Mathematics</th>
<th>Psychology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td></td>
<td>α</td>
<td>α</td>
<td>α</td>
</tr>
<tr>
<td>Certainty/simplicity</td>
<td>2.04 (.43)</td>
<td>3.50 (.64)</td>
<td>1.81 (.57)</td>
</tr>
<tr>
<td></td>
<td>.65</td>
<td>.62</td>
<td>.63</td>
</tr>
<tr>
<td>Source (four items)</td>
<td>2.75 (.67)</td>
<td>3.39 (.60)</td>
<td>2.71 (.54)</td>
</tr>
<tr>
<td></td>
<td>.61</td>
<td>.59</td>
<td>.54</td>
</tr>
<tr>
<td>Justification (four items)</td>
<td>2.70 (.43)</td>
<td>3.32 (.46)</td>
<td>2.56 (.58)</td>
</tr>
<tr>
<td></td>
<td>.69</td>
<td>.68</td>
<td>.71</td>
</tr>
<tr>
<td>Attainability (two items)</td>
<td>3.07 (.90)</td>
<td>3.75 (.81)</td>
<td>3.03 (.91)</td>
</tr>
<tr>
<td></td>
<td>.78</td>
<td>.81</td>
<td>.74</td>
</tr>
</tbody>
</table>

Instructions at the beginning of the questionnaire prompted students to reflect on their beliefs about knowledge for psychology, mathematics, or “everyday life” (for general knowledge). Students rated their agreement to each item using a 5-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree). Lower scores on this scale represent more constructivist beliefs (e.g., evaluativist beliefs), whereas higher scores reflect less constructivist beliefs (near the top of the scale represent absolutists beliefs), with the exception of the justification scale. For analyses reported in the following, however, for ease of interpretation, we reverse coded the justification scale.

Procedure

Participants were recruited through online and in-class advertisements. Each individual participated in a session that lasted approximately one hour. At the beginning of the session, participants were informed that there were three different versions of the same questionnaire. The participants were advised to carefully read the instructions and to reflect on their beliefs about knowledge in the domain specified at the top of the questionnaire. The interviewer then administered one questionnaire at a time, starting with the general knowledge questionnaire. The general knowledge questionnaire was presented first, given the possibility that completion of a more specific domain may be more influential on general knowledge responses as opposed to the other way around (see Muis et al., 2006). The order of the mathematics and psychology questionnaires was counterbalanced across participants.

The Interview

The interview was conducted after the participant completed all questionnaires. The interviewer asked participants about their beliefs about knowledge and knowing for mathematics, psychology, and general knowledge, using several items from the questionnaires as starting points for the interview. As such, students’ responses to the interview questions were contextualized in the items themselves. For example, an item was first read aloud and then the participant was asked to explain the reason why he or she selected a specific response for each domain, and

similar to the original domain-general instruments. Moreover, to be able to compare students’ beliefs across the three contexts, it was necessary to use the same instrument.
what came to mind when responding to the item. Students were also asked to provide examples to contextualize their beliefs. Participants were then asked questions that required them to discuss similarities or differences in their belief across mathematics, psychology, and “everyday life.” A mix of open-ended questions and structured questions were used throughout. One-word or brief responses were typically followed by probes to elicit further details (e.g., “Why/why not? When? How? What?” “Can you tell me more?”). Participants were then asked questions about their beliefs about “school math” and “psychology learned in school” and “math and psychology in the real world” to assess whether students’ beliefs differed across these contexts. For example, the interviewer asked: “Is math in the real world created or discovered? What about math in the classroom?” (See protocol in appendix.) All interviews were recorded using a digital recorder and transcribed verbatim.

Coding

A coding guide was developed through an iterative process of reviewing transcribed interviews. For the purposes of this study, the coding scheme for this approach was theory-driven (see Table 2 for definitions). The unit of analysis for segmenting each transcript was based on naturalistic segmentation using the response to each interview question as an indicator of a separate idea (Chi, 1997). Segments from transcripts that were considered relevant to these codes were marked; the remaining responses were excluded from analyses. Responses were then coded across domains using categories in the coding scheme to explore multidimensional and developmental belief patterns. While reviewing responses, coders conducted cross-case thematic analyses (i.e., identifying themes across multiple participants) and pattern analyses (i.e., identifying trends or relationships between multiple categories) that were evident across various domains and participants’ educational levels. We specifically noted when a theme appeared across the plurality of participants and when there were meaningful divergences from such prevailing themes.

After independently coding transcripts for four participants, three coders met to discuss categories, themes, and relevant quotations to verify consistency, following a procedure similar to that outlined in Creswell (2007a). Throughout the coding process, coders used the constant comparative approach to identify instances of categories of epistemic beliefs up to the point until no new insights were gained about those categories. To establish authenticity, direct quotations from students are presented in the results. Emerging themes and interpretations were verified with a subject-matter expert to establish credibility (Creswell, 2007b). Interrater reliability was established as 88% agreement. Disagreements were resolved through discussion with the subject matter expert.

RESULTS

Quantitative Analysis of the Relations Between General and Domain Specific Beliefs

First, all assumptions for repeated-measures analyses of variance (ANOVAs) were assessed. Skewness and kurtosis values for all subscale scores fell within a reasonable range, from −1.89 to 2.22 for skewness, and from −1.00 to 2.46 for kurtosis. Sphericity was also met for each
TABLE 2
Coding Scheme Used to Categorize Students’ Responses

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Range of beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolutism</td>
<td>Absolutists view knowledge as certain and absolute, rely on experts as the source for knowing, stress facts that reflect an objective reality, and express a high certainty about their own beliefs.</td>
<td>(not applicable)</td>
</tr>
<tr>
<td>Multiplism</td>
<td>Multiplists deny that experts can know anything with certainty, and are skeptical of experts in general. They recognize that experts can disagree and highlight that experts are inconsistent in their knowledge claims over time. Given the skepticism and distrust of experts, multiplists rely more on opinions and ideas over facts, and each opinion is equally correct.</td>
<td>(not applicable)</td>
</tr>
<tr>
<td>Evaluativism</td>
<td>Evaluativists deny the possibility of certain knowledge, recognize expertise and that experts may have multiple contrasting viewpoints. Multiple viewpoints should be compared and critically evaluated to assess their relative merits. Through critical evaluation, theories may be modified.</td>
<td>(not applicable)</td>
</tr>
<tr>
<td>Certainty</td>
<td>Certainty is the degree to which knowledge is more fixed versus more fluid.</td>
<td>Fixed—Knowledge cannot be doubted. Everyone would come up with the same answer to a question and the answer to a question will probably never change. Fluid—Knowledge is not certain. Answers to questions are the best we know now but knowledge evolves as more information is gathered.</td>
</tr>
<tr>
<td>Simplicity</td>
<td>Simplicity is the degree to which knowledge is more a set of facts versus more a network of highly interrelated concepts.</td>
<td>Set of facts—Knowledge is one fact after another and facts are unrelated. Answers are straightforward. Highly interrelated concepts—Knowledge is interconnected concepts. The meaning of one concept is complex, relative to others, and depends on the situation where the concept is used.</td>
</tr>
<tr>
<td>Source</td>
<td>Source focuses on whether people acquire knowledge from outside the self versus by actively constructing it within the self.</td>
<td>Outside the self—people believe knowledge is handed down by an authority (like a teacher or expert) and should not be questioned. Within the self—people believe they can construct knowledge by interacting with others, and using logic and/or evidence provided by experience.</td>
</tr>
</tbody>
</table>

(Continued on next page)
TABLE 2
Coding Scheme Used to Categorize Students’ Responses (Continued)

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Range of beliefs</th>
</tr>
</thead>
</table>
| **Justification**         | *Justification* focuses on how claims become accepted as knowledge by relying more on authority and experts versus relying more on personal experience and evaluation.* | Relying on authority and experts—people accept claims made by experts if experts reach consensus or agreement.  
Relying on personal experience and evaluation—people question experts, and evaluate information based on logic and/or evidence provided by experience. |
| **Attainability of truth**| *Attainability of truth concerns the degree to which an individual believes that ultimate truth is obtainable versus unobtainable.* | Obtainable—people believe it is possible to ultimately figure out the correct answer to any question and that there is a solution to every problem.  
Unobtainable means people believe that some things will never be known and some problems have no solution. |

analysis. Means, standard deviations, and Cronbach alpha reliability estimates for each of the four original dimensions in Hofer’s (2000) framework are presented in Table 1. Alpha was set at .01 for each of the four repeated-measures ANOVAs to examine variations in students’ domain-general and domain-specific beliefs (Question 1). Power for all analyses (including post hoc) was assessed, and a minimum power of .83 was achieved. As predicted, there was a main effect over the three domains for the certainty/simplicity of knowledge dimension, \( F(2, 64) = 131.86, p < .001, \eta^2 = .81 \). Post hoc analyses using the LSD revealed students’ beliefs differed across all three domains (all \( p < .001 \), \( d = .35 \) for the difference between general knowledge and psychology, \( d = -1.99 \) for general knowledge and mathematics, and \( d = -2.26 \) for psychology and mathematics). Specifically, students espoused more constructivist beliefs about psychology, followed by general knowledge, then mathematics. For the source of knowledge, there was a significant main effect, \( F(2, 66) = 19.15, p < .001, \eta^2 = .37 \). Post hoc analyses revealed that students’ beliefs about general knowledge and psychology did not differ (\( p > .50 \)), but that mathematics differed from both psychology (\( d = -1.28 \)) and general knowledge (\( d = -1.02 \), both \( p < .001 \)), wherein students espoused less constructivist beliefs about mathematics. For justification, there was also a significant main effect, \( F(2, 64) = 28.88, p < .001, \eta^2 = .47 \). LSD post hoc analyses revealed that, like the source of knowledge dimension, students’ beliefs about general knowledge and psychology did not differ (\( p > .20 \)), but that mathematics differed from both psychology (\( d = -1.50 \)) and general knowledge (\( d = -1.18 \), both \( p < .001 \)), wherein students espoused less constructivist beliefs about mathematics. Finally, for the attainability of truth dimensions, there was a significant main effect, \( F(2, 66) = 18.86, p < .001, \eta^2 = .36 \). LSD post hoc analyses revealed that students’ beliefs about general knowledge and psychology did not differ (\( p > .50 \)), but that mathematics differed from both psychology (\( d = -1.03 \)) and general knowledge (\( d = -1.85 \), both \( p < .001 \)), wherein students espoused less constructivist beliefs about mathematics.

We then examined correlations across each domain to examine whether students’ general and domain-specific beliefs were related (Question 2). We highlight a few interesting patterns here.
TABLE 3
Correlations Between Domains Across Dimensions of Epistemic Beliefs

<table>
<thead>
<tr>
<th></th>
<th>1</th>
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<th>3</th>
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<th>5</th>
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<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) CERT + SIMP Genrl</td>
<td>.29</td>
<td>.11</td>
<td>.20</td>
<td>*<em>.43</em></td>
<td>.23</td>
<td>.19</td>
<td>.27</td>
<td>*<em>.42</em></td>
<td>.06</td>
<td>.46**</td>
<td>.11</td>
<td></td>
</tr>
<tr>
<td>(2) SOURCE Genrl</td>
<td>-.15</td>
<td>.06</td>
<td>.20</td>
<td><strong>.67</strong></td>
<td>-.12</td>
<td>-.09</td>
<td>.21</td>
<td><strong>.08</strong></td>
<td>-.04</td>
<td>.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) JUST Genrl</td>
<td>.06</td>
<td>-.15</td>
<td>-.10</td>
<td><strong>.15</strong></td>
<td>-.08</td>
<td>.06</td>
<td>.05</td>
<td><strong>.30</strong></td>
<td>.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) ATTAIN Genrl</td>
<td>.01</td>
<td>.18</td>
<td>-.18</td>
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Note. Boldface denotes correlational statistics between two domains on the same dimension.

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

As shown in Table 3, for students’ beliefs about the certainty/simplicity of knowledge across the three domains, students’ beliefs about general knowledge and knowledge in psychology were moderately positively correlated (.43), as were their beliefs about general knowledge and mathematics knowledge (.42), and knowledge in psychology and mathematics (.31). Similarly, for the source of knowledge, students’ beliefs for general knowledge and knowledge in psychology were highly positively correlated (.67) but, unlike the certainty/simplicity dimension, students’ beliefs about the source of general knowledge and knowledge in mathematics were not related (.08), nor were their beliefs about the source of knowledge in psychology and mathematics (.20). For the justification dimension, there were moderate positive correlations between students’ beliefs about general knowledge and mathematics (.30), and psychology and mathematics (.37). Finally, for attainability of truth, there were high positive correlations between students’ beliefs about general knowledge and psychology (.65), and general knowledge and mathematics (.70), and a moderate positive correlation between psychology and mathematics (.50). Only four other correlations were significant across and within domains and dimensions. All other correlations were near zero. To help interpret these patterns of results, we turn to the interviews.

Qualitative Analysis of the Nature of Beliefs Across Educational Levels and Domains

The following sections describe results from analysis of participant responses from multidimensional (certainty, simplicity, source, and justification) and developmental perspectives (absolutism, multiplism, and evaluativism) across domains and educational levels. Although responses are interpreted from both developmental and multidimensional perspectives, it is important to note that students did not make consistent distinctions between each epistemic dimension from the multidimensional perspective. Specifically, under the developmental analytical lens, beliefs about absolutism, multiplism, and evaluativism were clearly distinguishable. However, with a
multidimensional lens, students alternated between talking about simplicity, certainty, justification, and source dimensions, and often interpreted justification and source as the same thing. This may indicate that students’ responses were consistently indicative of a particular developmental level, whereas their responses spanned numerous dimensions. Alternatively, this may also indicate that multidimensional beliefs may be more challenging to measure (see Muis, Duffy, Trevors, Ranellucci, & Foy, 2014). As such, we focus more on providing a rich description of students’ beliefs from the developmental perspective, but also provide examples from the multidimensional perspective to enrich these analyses.

**Mathematics**

Across educational levels, students’ beliefs about mathematics consistently reflected absolutist beliefs. Specifically, of the 34 students, 29 described mathematics as having “only one correct answer,” “one way to solve the problem”; one student claimed that “you can’t debate it” and another described it as being “all about absolutes.” For example, one secondary school participant described mathematics as follows: “In math, there’s only one answer. You can’t debate. Like, ‘2 plus 2 is four.’ You can’t say, ‘oh, my opinion is that it’s five.’” Similarly, a college student reflected: “If you’re talking about math, which basically usually has one answer, so whether even if they tell you this is the answer and you don’t understand it, it’s still the answer. There is always something that is the correct answer and you can’t say anything else about it.” Undergraduate and graduate students reported similar beliefs about the “black-and-white” nature of mathematics knowledge: “Math is all about absolutes [ . . . ] you either know something or you don’t” [undergraduate]. “When it came to math [ . . . ] I still have trouble thinking that actually my opinion could affect the answer. Like, I still feel like I have to find the right or the wrong” [graduate]. As another graduate student reported: “I’ve been brought up in system, or went through a school system, where the subject of math was very black and white. . . . It seems like within math, I just have to listen in order to get like, the right answer to succeed in the class.”

This trend suggests that, in general, there is little discernible difference in epistemic beliefs about mathematics knowledge for students who pursued specializations outside of this domain. There was, however, one exception to this general trend: Three students believed that although there is only one right answer, or possibly several correct answers, there are many ways or approaches to solve a problem and that those approaches are equally correct. In these cases, their responses suggest a multiplist stance for the procedural aspects of mathematics. For example, one secondary school student noted, “Math is not always like . . . there’s always different ways of doing it. There’s not just one right way of getting the answer. So if you find one way to get to the right answer, somebody else can find another right way. So there’s not just one way of getting to the truth. So there’s not really right or wrong. They’re equally correct.” And, as one graduate student remarked about mathematics being more a matter of opinion than fact, “I don’t really agree with that, because in math there is not a lot of room for interpretation for professors . . . there are equationary answers, and those can have room for interpretation and those interpretations are equally correct, but it doesn’t happen too often I’m guessing.”

Interestingly, one graduate student noted that individuals can have different answers or theories in mathematics and statistics, and that one perspective may be better than another depending on how the position is supported:
The stats class [...] is the first time that I’ve seen math sort of incorporated into real life, a little bit. So it’s breaking that boundary for me a little bit. That different experts might have different theories to do with certain, certain statistical or mathematical approaches. But generally, math has always been something that, uh, I guess I’ve been taught that there is a right or wrong answer. Which is why I put that. It’s not something that you could, that you could justify or argue your answer with a solid argument, or facts or points or your personal experience to further your answer. But in the stats class, the first time where, it’s kind of like, the theory of stats, that you can often explain and justify your answer, and that one answer may be better than another because it is justified better. So there is that little bit of . . . I’m starting to—that sometimes in math, maybe there is that little bit of room for that. But I still don’t see it as much as in my other education classes.

From a multidimensional perspective, analyses of transcripts revealed a pattern that was similar to the developmental findings: Across educational levels, 29 of the 34 students believed that mathematics knowledge is certain. As one secondary school student claimed, when it comes to mathematics, “It’s more known. What’s known is known. A lot what they got is from ancient Greece, I guess. So a really long time ago.” Similarly, a college student expressed that “Mathematics, because it can’t change, I don’t think it can change. What is known in mathematics, well, it can be maybe modified a bit but you can never come up with a different answer, just a different way to get to the same answer, so it’s nothing new really.” Even at the graduate level of education, students typically expressed a belief that mathematics knowledge does not change: “Personally I think I do agree that truth is really unchanging in math.”

However, although graduate students reported that mathematics knowledge is certain, two also noted that they could envision mathematics knowledge to be more tentative for mathematicians and students studying this domain more intensively: “From time to time you hear some people solve such and such famous problem that no one was able to solve until now. So, you know, there’s always truth that is not found yet.” This belief in the potential of tentative mathematical knowledge was further demonstrated by a graduate student who acknowledged that knowledge in mathematics may change more rapidly “at certain advanced levels of mathematics about topics that are cutting edge.” Thus, students’ responses suggested that lack of experience in mathematics might contribute to more fixed and simple beliefs for this domain.

Similar patterns were found for students’ beliefs about the source of knowing wherein the majority believed that mathematics knowledge was handed down by authority figures, as reflected in the following quotes: “You have rules and equations that you have to follow in order to get the answer [...] you can’t make something up, that’s the way it is” [secondary]. “If someone tells me like ‘oh this is the value we use for pi,’ you accept that it’s 3.14. You don’t really understand why or how you got it there but if it needs be plugged in, okay, you accept it without questioning it” [undergraduate]. “It’s not like you draw the picture. It’s already there, it already exists around you and then you understand it and you sort of like connecting, it’s not like connecting the dots but it’s like realizing the dots are already connected” [undergraduate]. “It’s just like memorize, because a lot of math is rules and stuff and like properties of certain things so what you do in math class is just like you practice using that so it’s more like it’s just like transmitted, I don’t think that there’s a lot of new stuff going on particularly at the undergraduate level.”

For justification, students frequently blended their responses about the source for knowing with processes of justification, and focused on answers to mathematics problems rather than on conceptual knowledge in mathematics. For example, one student reported that justification
in math was easier than psychology because “You just had to learn the formulas by heart and then just really practice to be good at it. If you get the same answer as the text, then that’s it, that’s your justification” [college]. Moreover, when responding to questions about mathematics knowledge “in the real world” versus in the classroom, all 34 students focused on their classroom experiences. There was no differentiation between “school” mathematics and mathematics in the “real world,” although in one case one student revealed that mathematics could be applied to carpentry.

**Psychology**

In contrast to mathematics, students in our sample adopted a multiplist stance toward psychology ($n = 27$). Rather than considering psychology as having one right answer, students typically believed that there are multiple opinions that are correct. As several remarked: “In psychology it’s always different people with different opinions” [secondary]. “I don’t think there’s ever one true answer in psychology” [undergraduate]. “You asked about correct answers in psychology. They are a matter of opinion and I think also to the people who read about these theories in psychology, it depends on their point of view too if it’s correct or not so that’s why it’s a matter of opinion because not everyone agrees on it” [college]. Undergraduate students held similar perspectives: “I don’t think there’s ever one true answer in psychology. [. . . ] I don’t think that experts, no matter how good they are, could actually get one answer.” “For psychology I feel that there is always room for interpretation. I think it is like your opinions matter and facts are kind of like the base upon which you argue for your opinion. You can’t have an opinion without having a reason.”

Furthermore, at the undergraduate and graduate levels, there was evidence that six students espoused more evaluativist beliefs for psychology: They commented on the importance of analyzing experts’ arguments and noted that there was greater room for interpretation as noted by these undergraduate and graduate students, respectively: “If there’s really contrasting theories from like all of these different psychologists, chances are one of them is like really predominant, but you’ll still learn about all, gonna memorize them equally for some test, but in the real world chances are only one of them will apply to the majority and only a few will apply to some minorities.” “To elaborate on something that psychologists work on they would probably have to talk and talk and talk, and someone who is a non-psychologist would have to really pay attention and try to follow their arguments and then decide who has the best position.”

An exception to these multiplist and evaluativist beliefs was observed for a secondary school student whose unwavering trust in experts’ opinion suggested a more absolutist stance for psychology. Interestingly, this student suggested that her lack of formal educational experience in this domain might be one reason why she would be more inclined to adopt this stance: “I don’t know it [Psychology], so I’d agree with the expert . . . ’cause I wouldn’t question him ’cause I don’t know it. I don’t have anything to question ’cause I don’t have any other source I could question from, like, yeah . . . nothing to compare to.”

Consistent with the trends from the developmental perspective, analyses from the multidimensional perspective revealed that students believed psychology to be more tentative and complex. Students commented that knowledge in psychology is in a state of constant change and evolution, with new ideas emerging everyday: “I believe that ideas in psychology would be more complex rather than basic because um, for the fact that you’re human and there’s more factors, like body
language and stuff. It’s not just a simple idea. There are a lot of factors and they’re related” [secondary]. “But in psychology, we’re coming with new ideas everyday” [secondary]. “In psychology, our brains are always coming up with new theories about stuff we thought we knew and we come up with something that makes more sense so that’s why, so I think it can constantly change” [college].

However, students’ justification for knowing in psychology appeared to be more variable. This variability may be accounted for by a recurring theme related to beliefs about justification: students differentiated between “opinions” and “facts” in psychology, and held different epistemic beliefs for each. For example, one secondary student commented on the role of comprehension for the evaluation of knowledge claims in psychology: “when you understand [another person’s] opinion, you’re more likely to believe their opinion. But when it’s a fact [. . . ] it’s always the right answer—you don’t have to understand this.” Yet another student at the undergraduate level reported a belief in “transmitted” psychological knowledge, which indicated a belief in justification by authority (i.e., a university instructor). When explaining his beliefs, this student noted that although he believed psychology to be “more of a subjective field,” he recalled the way knowledge was typically presented in psychology courses, a way that essentially facilitated taking notes: “I think that’s another thing where it is just transmitted because even if it is more a subjective field, in classrooms, it’s basically just like taking notes so I don’t think the students do very much discovering stuff on their own.” Thus, these broad variations appeared to be linked to the diverse academic and classroom experiences in this domain, which were different from those experiences with general “everyday knowledge.”

For the source for knowing, students were likewise conflicted and held a broad range of epistemic beliefs. One secondary student noted a common belief shared among many, namely, that she has to meet a standard of comprehension for knowledge claims before she was willing to accept them. However, another student remarked that he had not thought “about this stuff too much [. . . ] because it’s kind of pointless [. . . ] it’s better just to accept it and just like mimic,” and stated that he preferred “to have fun” rather than “asking why.” Another common belief across students was the notion of finite resources, such as time, with which to evaluate experts’ claims; one undergraduate student explained that “one person can’t know everything so after a certain point [. . . ] I trust these people know what they’re doing because I just don’t have the resources myself to research all that.” Thus, students maintained a standard of comprehension for many knowledge claims, which promoted personal justification, but lacked motivation and resources to test these claims, which potentially lowered students’ standards for comprehension and increased the likelihood of unquestioned acceptance of expert claims.

Another trend that we found particularly noteworthy was that when describing their beliefs about knowledge in psychology, all college, undergraduate, and graduate students who had taken at least one psychology course reflected on their classroom experiences, as noted in the following quotes by students: “I love that my teacher uses practical examples in our psychology class from real life to explain almost anything. And it makes a lot of sense, you know? And there is so much that I didn’t know, or the names of things or about how things work like how we hear” [college]. “I studied in psychology, so I had the opportunity to take many classes in which opposing views are presented sometimes and they do this a lot, they love doing this, where they’ll talk about one specific process and then will give two different views on the subject” [undergraduate]. To a much lower extent, students also drew examples from psychology in the “real world context.” In
contrast, secondary school students and other students, who had not taken a psychology course, drew more on real-world examples but on occasion also discussed other classes, such as “biology and how the brain works,” to link that to psychology, as reflected in the following quote by a secondary school student:

So, psychology, if we’re learning about everything else, we might as well learn about ourselves. Like, even in school, we take stuff apart like when you dissect stuff to learn how the animal works to give you a better understanding. And the human, if you take him apart and study him further, you get to understand why we think in certain ways, why we act, what motivates us, stuff like that.

Similarly, another secondary school student drew on other classroom experiences when asked about his or her beliefs about mathematics: “We don’t have psychology classes, but sometimes our teachers tell us about human behavior.” As such, we inferred that even when students had little to no classroom experience from which to derive their answers, students relied on classroom experiences in other domains to formulate their answers.

**Everyday Life**

Similar to students’ beliefs about psychology, students across all education levels commonly espoused multiplist beliefs for knowledge in everyday life ($n = 31$), as represented in the following quotes from students: “Opinion isn’t right or wrong” [secondary]. “Everyday life is subjective, that’s why it’s complex, because it depends, it’s relative, it’s not . . . [ . . . ] There are different ways of explaining the same things, so there are different points of views on the same things” [college]. “So in everyday life there could be many correct answers to one thing, so it is more a matter of opinion, because different people would have different opinions. Maybe their opinions are all right, are all correct answers” [graduate].

College students also believed that knowledge in everyday life was subjective, and contrasted this subjectivism with the objective nature of mathematics, as revealed in the following quotation: “Something that is objective versus subjective, so math to me is very objective and psychology and everyday life is subjective, that’s why it’s complex, because it depends, it’s relative.” However, three upper-level undergraduate and graduate students began to demonstrate more evaluativist beliefs about everyday knowledge by indicating that providing “really good reasons” for why an answer was correct and evaluating that answer were necessary before making a decision as to whether something was certain or not.

From a multidimensional perspective, across all interview transcripts, students’ interview responses infrequently implied a multidimensional interpretation. However, this paucity was particularly evident for the everyday life scale, and for responses concerning the simplicity and certainty dimensions. Despite this, what was noteworthy with students’ beliefs about knowledge in everyday life was that, unlike mathematics or psychology, students believed that if they did not understand something then it could not be considered true, as depicted in the following quotes from two secondary school students: “If you don’t understand something, you can’t accept it. You have to question it, until you understand it. By accepting it you don’t really get it in your head, by understanding it, you connect it in your head.” “The experts might be right, but in general they might be wrong, so we have to understand what they’re talking about before I listen
to them. I can’t just accept it.” Perhaps because mathematics and psychology have definitive experts, students are more likely to accept what experts say constitutes knowledge. However, for general knowledge, perhaps because of the variability in what this might entail, and the lack of a definitive “general knowledge expert,” students were more likely to place higher standards for justification on themselves, which entailed personal understanding as a standard for justification.

**Students’ Comparisons of Mathematics to Psychology**

To help interpret the significant means differences in the repeated-measures ANOVAs and moderate correlations found in students’ responses to their beliefs about mathematics and psychology, we draw on direct comparisons that students made in their interviews. What we found particularly noteworthy was that students reported believing that knowledge in psychology was in flux, but that knowledge in mathematics was fixed. This was supported by the low positive correlation in students’ responses on the self-report scale (e.g., scores were not similar across scales). Despite this low correlation, there were some similarities, which we describe here. First, as noted earlier, students across age levels differentiated between declarative knowledge and procedural knowledge in mathematics, wherein the latter was associated with greater beliefs in uncertain knowledge. For example, one secondary student reported experts in mathematics are constantly innovating: “If they find the area of a rectangle, there might be another way to do it, they can always find new ways of doing things.” Another noted that while there is certainty in mathematical answers, “there can be different ways to get to the answer.”

Second, graduate students reported envisioning the possibility of uncertain mathematics knowledge. Interestingly, these students seemed to draw upon their relatively deeper experience with psychology to make their assessments. For instance, one graduate student reported believing that knowledge in psychology “seem[s] to be in a constant state of change,” and could speculate that the same was true for mathematics “at certain advanced levels [. . . ] about topics that are cutting edge, but I’m not very aware of those.” Another graduate student made a similar connection between psychology and mathematics on epistemic certainty: “I feel like psychology is still really a developing field [. . . ] and there are still papers, publications, studies that are coming out on new aspects of it, whereas maybe it is not published but is happening in the same way for mathematics.” Taken together, students reported a broad range of epistemic beliefs concerning the certainty of mathematics knowledge. Deriving examples about one domain (e.g., psychology is still developing) to respond to questions about another domain (e.g., mathematics might be similar to psychology in that regard) may help explain the moderate correlations that were found in the quantitative analyses.

In summary, qualitative analyses of interviews with students revealed that students’ absolutist beliefs toward mathematics knowledge often persisted well into their postsecondary education, but with some notable departures from this trend. In contrast, for everyday life and psychology, students across educational levels generally reported beliefs in line with a multiplist stance, and even some instances of evaluativist beliefs among students at higher levels of education. These findings suggest that students’ beliefs about knowledge and knowing shifted based on an interaction between the domain and their level of experience, and when experience was lacking, these students often relied on experiences with other domains. A summary of the qualitative and quantitative results is presented in Table 4. Implications of these findings are addressed next.
TABLE 4
Summary of Results

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<th>Justification</th>
<th>Source</th>
<th>Attainability of truth</th>
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<td>Quantitative results</td>
<td>$\Psi &gt; \text{GK} &gt; \text{Math}$</td>
<td>$\Psi = \text{GK} &gt; \text{Math}$</td>
<td>$\Psi = \text{GK} &gt; \text{Math}$</td>
</tr>
<tr>
<td>Qualitative results</td>
<td>Primarily multiplist beliefs; knowledge is tentative and complex; justification and source demonstrated mixed beliefs</td>
<td>Primarily multiplist; knowledge is tentative and complex</td>
<td>Primarily absolutist; knowledge is certain and handed down by an authority figure</td>
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*Note.* $>$ Means more constructivist beliefs. $\Psi = \text{Psychology}$. GK = general knowledge.

DISCUSSION

The purposes of this study were to empirically evaluate the Muis et al. (2006) TIDE framework to examine whether students espouse general knowledge beliefs and more domain-specific beliefs, and to assess the nature of similarities and differences in students’ beliefs. Based on means analysis and the correlations between the same dimensions across different domains, results from our study suggest students’ beliefs are somewhat related but still unique to that particular domain. Moreover, results from the interviews revealed that students do indeed espouse more general knowledge beliefs and domain-specific beliefs and that students draw on their experiences from one domain to provide responses about another when experience is limited. Analysis of the interviews also revealed that the majority of students, regardless of educational level, expressed more absolutist beliefs about mathematics, but were more multiplist in their stances toward psychology and general knowledge. We discuss the theoretical implications of our research next.

Theoretical Implications

From a theoretical standpoint, our results have important implications, particularly with respect to the Muis et al. (2006) TIDE framework. Specifically, Muis et al. proposed an integration of both developmental and multidimensional frameworks wherein development moved from absolutism through to evalutativism across the four dimensions. Moreover, they proposed that individuals’ epistemic beliefs are socially constructed and that development occurs as a function of interactions with the social world wherein both life experiences and educational experiences fine-tune individuals’ beliefs over time. Through educational experience, and particularly experiences in the classroom context, individuals’ beliefs are shaped. Muis et al. also proposed that individuals espouse both general knowledge beliefs and more domain-specific beliefs. Results from our study support these propositions but also suggest that a more fine-tuned consideration of students’ beliefs from a multidimensional perspective be taken into consideration, given that students’ reflections on their beliefs did not often align with the four epistemic belief dimensions.

In particular, analysis of interviews with students from secondary through to graduate school revealed that students’ espoused beliefs were more often aligned with absolutism, multiplist, or
evaluativism. In contrast, students did not often articulate beliefs in ways that provided evidence for the multidimensional frameworks. We find this particularly noteworthy given that others have reported evidence of the four dimensions but in the context of using think-aloud protocols during task completion to capture students’ beliefs (e.g., Ferguson, Bråten, & Strømsø, 2012; Hofer, 2004). Our study differs from these, however, in that students were not presented a task to complete, but were asked to discuss their beliefs outside of a particular learning context. It may be the case that beliefs from a developmental perspective are more salient in these more general contexts, which supports other developmental frameworks that also applied in-depth interviews to assess students’ beliefs. What we find particularly puzzling, however, is that interviews were based on the very items designed to measure their beliefs from a multidimensional framework. At the very least, our results speak to the importance of how beliefs are measured and under what context they are assessed. As Bromme, Pieschl, and Stahl (2010) have highlighted, contextual differences may play an important role in students’ expressed and enacted beliefs, and such nuances must be taken into consideration in addition to how beliefs are measured. Certainly, in our interviews, students’ responses were often contextualized in their classroom experiences, particularly for their domain-specific beliefs.

**Educational and Classroom Experiences**

Students in our study had limited exposure to mathematics beyond their secondary school years. As such, during interviews, students often highlighted their lack of experience in the mathematics domain and were more likely to espouse absolutist beliefs about mathematics. For example, consistent with previous research (Diaz-Obando, Plasencia-Cruz, & Solano-Alvarado, 2003; Fleener, 1996; Frank, 1988; Garofalo, 1989; Kloosterman & Cougan, 1994; Schoenfeld, 1988), students across all four levels of education in our study generally believed that mathematics knowledge is certain and absolute, and that only experts can construct mathematics knowledge. As students noted, teachers tell them what to do and how to do it when it comes to learning mathematics; there is no room for questioning authority or developing their own conceptions of what it means to know. Students viewed mathematics knowledge as something that is to be memorized and regurgitated without critical consideration of what they are learning, which is consistent with previous research on students’ beliefs about mathematics (see Muis, 2004).

In contrast to their experiences in mathematics and beliefs about mathematics knowledge, students across all levels of education were more likely to espouse multiplist or evaluativist beliefs about psychology, even when students had little experience in psychology, with some notable exceptions. We attribute differences in students’ beliefs between mathematics and psychology to a number of factors. First, students reported very different classroom experiences in psychology compared to those in mathematics. Students were frequently exposed to opposing views and were encouraged to engage in debate over topics in psychology. This experience stands in sharp contrast to students’ reported experiences in mathematics classes, where the emphasis was on correct usage of given formulas and the search for the one “right answer.” Thus, differences between the contexts and methods in which students encountered and were presented with mathematical and psychological knowledge were active and influential when students were reflecting on their epistemic beliefs.

Second, when students had limited exposure to psychology they based their responses on their everyday experiences. This highlights students’ leveraging of experience from one domain
(general life) to make sense of issues from another, less familiar domain (psychology). With such perceptions, other students noted that they would be more willing to accept expert testimony when the students themselves felt they lacked the knowledge to question the expert and had “nothing to compare” to the expert’s claims. Such a position stands in contrast to other students’ positions: students who reported their desire to understand expert claims prior to accepting them. It seems then that an unquestionable acceptance of testimony from authoritative sources, rather than a more complete comprehension, varies as a function of prior knowledge; a perceived lack of prior knowledge resulted in students reporting more certain beliefs and a reliance on authorities. Thus, prior academic experience in psychology appeared to be a crucial factor for students when reflecting on issues related to their epistemic beliefs.

For mathematics, however, students rarely elicited memories that were not affiliated with some classroom or school experience. This finding is consistent with previous research (e.g., Schoenfeld, 1988) wherein students reported not seeing the inherent value of mathematics beyond the classroom, or considered its relevance in a real-world context. Given students’ interview responses for general, mathematics, and psychology knowledge, we suggest that not only are students’ beliefs influenced by the classroom and school experiences, but they are also shaped by experiences in everyday life, particularly for beliefs about knowledge in psychology, which is consistent with the Muis et al. (2006) framework. Of course, students’ beliefs are likely shaped by other factors as well, such as familial influence (Schommer, 1994), but students did not reflect on these experiences during the interviews.

**Domain Specificity and Reciprocity of Beliefs**

Results from our study also support the Muis et al. (2006) and Buehl and Alexander (2006) position on the domain specificity and generality of individuals’ beliefs. Specifically, as several theorists have proposed (Buehl & Alexander, 2001; Buehl et al., 2001; Hofer, 2000; Op ‘t Eynde & De Corte, 2003), different epistemologies may apply to different domains of knowledge (Muis et al., 2006), but developmentally predictable patterns in the development of epistemic beliefs across different domains may be similar (e.g., Belenky et al., 1986; Kitchener & King, 1981; Perry, 1970). From a multidimensional perspective (e.g., Schommer, 1990), the structure of knowledge, sources of knowing, certainty of knowledge, and how knowledge is justified may be different for phenomenological, empirical, and analytic approaches to knowing. Developmentally, however, individuals may initially espouse an absolutist perspective and gradually develop a more evaluativist perspective of the different domains of knowledge.

Of particular relevance, Muis et al. (2006) proposed that instructional contexts influence the development of domain-specific epistemic beliefs, but they further suggest a reciprocal relationship between each of the domain-specific epistemic beliefs. That is, beliefs about one domain may relate to beliefs about other domains. In our study, we found that students across all levels of education held very distinct beliefs about mathematics compared to psychology and everyday life but that responses were also moderately correlated. However, at the upper graduate level of education, despite the persistence of absolutism beliefs about mathematics, they presented evidence of a belief that if given more experience, they could think of mathematics knowledge in more evaluativist ways. That is, graduate-level students were able to be more reflective about mathematics knowledge, and acknowledged that with a greater prior knowledge base, they could see themselves believing that knowledge in mathematics could be more tentative,
that disagreements in what is considered “true” are feasible, and they could envision others constructing their own knowledge in that domain. Notably, these graduate students drew upon their relatively more advanced beliefs in psychology to infer that an analogous reality may exist for mathematical knowledge.

Finally, results from our study support previous research that has found differences in students’ epistemic beliefs as a function of educational and life experiences (King, Wood, & Mines, 1990; Schommer, 1994). In particular, we found that as students progressed through higher levels of education, their beliefs about psychology and everyday life became more evaluativist. Moreover, consistent with Kuhn’s (2000) position on the development of epistemic beliefs, we found distinct patterns as a function of domain. It appears that students’ epistemic beliefs about various domains do not develop in synchrony, and that classroom, school, and real-world experiences may play a significant role in shaping these beliefs.

Educational Implications

Given previous research on students’ beliefs about mathematics (for a review see Muis, 2004), it comes as no surprise that students relied primarily on their classroom experiences to describe their beliefs about mathematics knowledge. Unfortunately, these classroom experiences are not always conducive to more constructivist beliefs. Since the late 1980s, the National Council of Teachers of Mathematics (1989) has made explicit calls to teachers and teacher-training programs to shift instructional practices to change students’ beliefs about mathematics to improve learning outcomes. We question whether any change in instructional practices has occurred, given the descriptions students in our study offered of their mathematics classroom experiences. Clearly, for students to see the inherent value in mathematics, and to connect it to the “real world,” students need to be given authentic tasks. Students also need to be given more control over their learning, as opposed to being told what to “memorize” and “regurgitate.” On a positive note, however, particularly at the graduate level, students were able to envision how mathematics might be construed as tentative and evolving.

Likewise, for psychology and everyday life, to foster more evaluativistic thinking about knowledge, we recommend that teachers and professors allow room for debate about topics covered, and to connect content to the real-world context. Students should be trained to think critically about content, and be presented with conflicting information about topics or, at the very least be presented with debates about the content that are current in each respective field. As Muis and Duffy (2013) found, providing these opportunities for students, coupled with modeling and scaffolding of critical thinking, may result in epistemic change toward more constructivist views about knowledge and knowing.

Limitations and Future Directions

Clearly, the interviews with students provided a much richer account of the nature of their epistemic beliefs, information that could not possibly be extracted from a sole reliance on self-reports. Moreover, given that self-report measures of epistemic beliefs have been highly criticized in the literature (see Debacker et al., 2010), we believe the interviews enabled us to explore more deeply how students’ beliefs compared and contrasted across levels of specificity. For example, low subscale reliability has plagued research in this area, and some of the subscales we measured in
our study suffered the same fate. As such, we believe it is critical to triangulate methods by which beliefs are measured. Unfortunately, we did not follow these individuals over time to explore how changes in learning environments may or may not foster change in beliefs. As such, our analyses were cross-sectional in nature. We can only infer that their educational experiences relate to their beliefs, but also acknowledge that many other factors may also relate to students’ beliefs other than school contexts. Our results are also limited to students’ beliefs about mathematics, psychology, and everyday life. Would similar patterns of responses arise with different domains such as physics and history? Certainly, our results are limited in generalizability to the domains we chose for our research.

Additionally, our sample size was small and, as such, the quantitative results must be interpreted with caution. It would also be fruitful for future research to sample students from diverse backgrounds, such as undergraduate and graduate students from mathematics, as they likely espouse quite different beliefs about mathematics compared to students enrolled in social science domains. Moreover, much more work is needed to chart the Muis et al. (2006) TIDE framework. Do academic beliefs exist and do they begin at the commencement of formal education? How do academic beliefs relate to domain general and more specific beliefs? How do beliefs change over time with experience? What environmental conditions facilitate or hinder the development of beliefs? What would belief change look like for children aged 4 through 8? Questions such as these still remain unanswered, particularly for epistemic belief development in preadolescence. Much more longitudinal work is needed, like Perry’s (1970) original work that followed individuals over their educational experiences during their undergraduate years. The current study begins to shed some light, but we hope that future work will provide insight into these pressing questions. For now, we believe results from this study will inform future work and hope that it motivates others to continue to test the TIDE. In conclusion, results from our study have important theoretical, practical, and measurement implications. Clearly, students do distinguish different levels of beliefs, and how researchers measure these beliefs and at what level of specificity may have important implications for tapping into relations between epistemic beliefs and various facets of learning.

AUTHOR NOTES

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**APPENDIX:** Interview Protocol

1. Students complete three epistemic beliefs questionnaires (i.e., everyday life first, then psychology, mathematics—in random order).
2. Conduct interview immediately after participant completes the questionnaires.
3. For each survey item selected, ask participant to reread the item out loud.
4. Ask the following cognitive questions after the participant has read the item out loud (same format for all items):
   a. What is this question trying to find out from you?
   b. Which response did you choose?
   c. Can you explain to me why you chose that response?
   d. [Choose an item that had similar/different responses across the domains or in contrast to everyday knowledge.] You chose the same/different answers for [domain]. Can you tell me why?
   e. When it comes to [domain], do you think it is created or discovered?
   f. Do you think [domain] in the real world is similar to [domain] in school?
Example follow-up probes (When initial responses do not provide sufficient information):

**Question 1:**

“Can you tell me a little more about what that item means to you?”

“Can you tell me a little more about what you think the point of this item was?”

“Can you tell me a little more about what you think this item was trying to ask/say?”

**Question 2:**

Very straightforward question; shouldn’t require a follow-up prompt.

**Question 3:**

“Can you tell me a little more about why you chose that response?”

“What were you thinking about when you selected that response?”

“Did you have a specific example in mind?”

**Question 4:**

“What makes them the same/different?”

“Did you have similar/different examples in mind?”

**Question 5:**

“So do you think they are related (i.e., answers for each domain)?”

**Question 6:**

“Do you think that [domain] knowledge you learn in school is useful for the real world?”