WCER Working Paper No. 2012-10
October 2012

A Situative Analysis of the Relationship between Faculty Beliefs and Teaching Practice:

Implications for Instructional Improvement at the Postsecondary Level

Matthew Tadashi Hora
Researcher
Wisconsin Center for Education Research
University of Wisconsin–Madison
hora@wisc.edu

WCER

Wisconsin Center for Education Research
School of Education • University of Wisconsin–Madison • http://www.wcer.wisc.edu/

WCER working papers are available on the Internet at http://www.wcer.wisc.edu/publications/workingPapers/index.php. Recommended citation:

> Hora, M. T. (2012). *A Situative Analysis of the Relationship between Faculty Beliefs and Teaching Practice: Implications for Instructional Improvement at the Postsecondary Level* (WCER Working Paper No. 2012-10). Retrieved from University of Wisconsin–Madison, Wisconsin Center for Education Research website: http://www.wcer.wisc.edu/publications/workingPapers/papers.php

A Situative Analysis of the Relationship between Faculty Beliefs and Teaching Practice:

Implications for Instructional Improvement at the Postsecondary Level

Matthew Tadashi Hora

A long-standing question in education is to what degree teachers' planning and classroom practice is influenced by their pedagogical thoughts in general and beliefs about teaching and learning in particular. Drawing on theory and method from cognitive psychology, researchers of K–12 teacher thinking have established that teaching is a complex practice that is informed by both conscious and subconscious cognitive characteristics of individual teachers and features of the immediate instructional context. Beliefs, particularly those regarding how students learn, play a unique and influential role in this process by filtering new information, framing problems, and guiding action in concert with other mental representations as well as features of the immediate task environment (Fives & Buehl, 2012; Nespor, 1987). This focus on beliefs is not limited to educational research but is a fundamental problem addressed by fields as diverse as public health (Armitage & Connor, 2000), ethical decision-making in organizations (Trevino, 1986), and religious practice (Geertz, 1973), thereby underscoring the fundamental role that beliefs are thought to play in shaping cognition and behavior.

Extensive research at the postsecondary level has similarly examined how the pedagogical thoughts of faculty influence their teaching practice, using a variety of constructs with which to conceptualize faculty cognition such as approaches to teaching (Prosser, Trigwell, & Taylor, 1996), conceptions (Pratt, 1992), and beliefs (Samuelowicz & Bain, 1992, 2001). In general, this literature advances two propositions regarding the nature of the relationship between beliefs and practice. First, researchers have found that the pedagogical thoughts of postsecondary teachers can be characterized as existing on a continuum from student-centered to teaching-centered orientations, with attendant implications for the quality of instruction and student outcomes (Kember, 1997). Second, researchers suggest that a thematic relationship exists between such approaches, classroom practice, and student outcomes, and that efforts to improve educational outcomes should support faculty in obtaining the student-centered perspectives (Gibbs & Coffey, 2004; Ho, Watkins, & Kelly, 2001).

However, this body of literature has been critiqued for insufficient conceptualization of psychological constructs, lack of attention to the influence of organizational contexts, and the tendency of researchers to rely exclusively on self-report data without observing actual classroom practice (Kane, Sandretto, & Heath, 2002). Further inhibiting this body of work is that little is known about how faculty ideas about a particularly influential belief—that of how students learn—actually influences their instructional decision-making. Finally, higher education researchers tend to not draw upon theory or method from the literature on teacher cognition from the K-12 sector, or cognitive psychology upon which this body of work is based (Entwistle, Skinner, Entwistle, & Orr, 2000; Lattuca, 2005). Thus, the postsecondary literature lacks theoretically informed explanations of the relationship between faculty beliefs and teaching, and the role of other cognitive and contextual factors in mediating this relationship.

A promising line of inquiry on faculty practice draws on situated cognition theory, which emphasizes how cognitive processes are embedded in particular settings, to explore the problem of how and why faculty make particular teaching-related decisions (Norton, Richardson, Hartley, Newstead, & Mayes, 2005). In this paper I elaborate upon this approach by drawing on the situative perspective of Greeno (1998) to investigate the beliefs regarding student learning held by faculty, and how these beliefs interact with other factors to shape the emergent problem space of instruction for individual instructors (Greeno, 1998). In this study I analyze interview and classroom observation data using a variety of analytic approaches including inductive and thematic network analysis, and data reduction techniques (i.e., cluster analysis and multidimensional scaling). I make the case that while faculty can be characterized as having beliefs that emphasize the student or teacher as the constructor of knowledge and learning, individuals cannot adequately be typified as having a single “type” belief and that a direct and thematic correspondence between beliefs and practice should not be assumed. The research questions guiding the study are: (a) What beliefs do faculty have for how undergraduate students learn in their discipline? (b) What, if any, underlying dimensionality exists for these beliefs? (c) How, if at all, do beliefs interact with other factors to influence how faculty plan and teach their classes?

Background

In this section I review the literature on teacher beliefs at the postsecondary level. Then, I turn to research on K–12 teacher beliefs and aspects of cognitive psychology upon which this literature is based. Finally, a brief discussion of reform implementation situates the analysis within the broader context of educational improvement at the undergraduate level.

Research on Faculty Beliefs

A substantial amount of research exists on faculty thinking and beliefs (see Hativa & Goodyear, 2001 for a review). However, few higher education researchers in this area reference the K–12 literature on teacher cognition in general, and cognitive psychology in particular (Entwistle, Skinner, Entwistle, & Orr, 2000; Lattuca, 2005). Instead, a parallel yet distinct line of inquiry developed on faculty thinking in the early 1990s that continues to the present time. Researchers in this area have investigated and developed a variety of terms and constructs. For example, in his review of 13 studies on faculty thinking, Kember (1997, p.256) noted that researchers had used the following terms: “orientations, conceptions, beliefs, approaches, and intentions” and that few definitions had been offered for these constructs. Kane, Sandretto and Heath (2002) argued that this situation was contributing to terminological confusion, echoing the sentiments of Pajares (1992) in his assessment of the literature on K–12 teacher cognition. More recently, researchers have more carefully articulated the constructs used in their studies (e.g., McAlpine, Weston, Timmermans, Berthiaume, & Fairbank-Roch, 2006).

Higher education researchers have studied topics such as the beliefs of exemplary teachers (Hativa, Barak & Simhi, 2001), faculty self-concept (Roche & Marsh, 2002) and self-efficacy beliefs (Bailey, 1999), and beliefs about effective teaching (Samuelowicz & Bain, 1992). In one of the few studies focused on faculty beliefs about how students learn, Prosser, Trigwell, and Taylor (1996) interviewed 24 chemistry and physics faculty, asking them "What do you mean by teaching and learning in this subject?" and "How do you know if a student had learned something in this course?" In this study, the researchers identified five conceptions of learning: (a) learning as accumulating more information to satisfy external demands, (b) learning as acquiring concepts to satisfy external demands, (c) learning as acquiring concepts to satisfy internal demands, (d) learning as conceptual development to satisfy internal demands, and (e) learning as conceptual change to satisfy internal demands. Prosser, Trigwell and Taylor argued that these beliefs varied by whether the belief placed emphasis on external (e.g., departmental or instructor expectations) or internal (e.g., learner expectations) demands regarding the purpose of learning. One aspect of this dimensionality (i.e., external to internal) pertains to the manner by which meaning and understanding is acquired. For conceptions (a) and (b), it is through acquiring objective knowledge and facts from textbooks or lectures. Judgments regarding whether or not learning has occurred is subsequently based on performance on assessments that are created by and evaluated according to the expectations of the department and/or instructor. In contrast, for conceptions (c), (d), and (e), learning involves the student developing his or her own meaning of the material. In verifying the quality of the knowledge obtained by students, tests play an important role but faculty holding these beliefs reported that it is the student who determines "when they have learned something because it will have personal meaning for them" (Prosser, Trigwell, & Taylor, 1996, p.221).

The authors also argued that these beliefs could be logically ordered into a hierarchy such that conception (e) encompasses all other conceptions, with conception (e) being the most pedagogically sophisticated. The characteristics underlying these beliefs about student learning served as the conceptual basis for the development of the "approaches" to teaching research program, which posits that teaching approaches (i.e., an individual's intentions and strategies) are thought to vary from a teacher-centered category where instructors tend to view teaching as the delivery of content to passive students, to a student-centered category where instructors view teaching as the active facilitation of student learning (Trigwell, Prosser, & Taylor, 1994). Interestingly, since the early work of Prosser, Trigwell, and Taylor (1996) no empirical research focused exclusively on faculty beliefs about student learning has been conducted.

The notion that faculty thinking in general varies along a student- and teacher-centered dimension is widely shared in the literature (Kember 1997; Samuelowicz & Bain, 1992). Some view these dimensions as mutually exclusive points on a single continuum, such that individual faculty can be identified as holding a particular type of approach (Trigwell & Prosser, 2004). Further, many researchers argue that a direct relationship exists between these approaches and an instructor's classroom practice (Gibbs & Coffey, 2004; Samuelowicz & Bain, 2001). For example, Kember (1997, p. 270) states that "a lecturer who holds an information transmission conception is likely to rely almost exclusively on a unidirectional lecture approach," and

Trigwell, Prosser, and Waterhouse (1999) argue there exists a “chain of relations from teacher thinking to the outcomes of student learning (p. 67).”

However, the research program on faculty thinking and related assumptions regarding the functional relationship between thought and practice have come under criticism in recent years. Some researchers suggest that higher-order constructs such as “approaches” to teaching represent de-contextualized thoughts that bear little resemblance to the actual plans and decisions made by faculty in specific teaching situations (Eley 2006; Norton, Richardson, Hartley, Newstead, & Mayes, 2005). Other critiques center on the assumption that individual faculty can be typecast as having a single “type” of beliefs. Postareff and Lindblom-Ylanne (2008) suggested that research on approaches to teaching should go beyond the student/teacher-centered dichotomy and that “a strong opposite ‘either/or’ positioning of the approaches does not do justice to the nature of the phenomenon.” (p.120). Finally, some researchers suggest that the relationship between faculty thinking and actual teaching practice is far more complex than is posited by the formulation that faculty beliefs and approaches determine practice (Kane, Sandretto, & Heath, 2002; McAlpine et al, 2006). While promising research examining the details of faculty decision-making exists (e.g., Henderson & Dancy, 2007), little is known about the role that contextual factors may play in mediating the relationship between beliefs and practice. Given that little is known about the characteristics of faculty beliefs about student learning as well, the field of higher education would benefit from an improved understanding of the nature of these beliefs and how, if at all, they influence instructional practice. I suggest that research on K–12 teacher cognition in general, and the theoretical framework advanced by situative theorists in particular, have the potential to advance the field of higher education’s understanding of these critical issues. I now turn to a brief review of key ideas from these bodies of research.

Research on K–12 Teacher Cognition

An extensive literature exists on K–12 teacher cognition in general, and on teachers’ pedagogical beliefs in particular (see Kagan, 1990; Pajares, 1992; Fives & Buehl, 2012 for reviews). Within the literature researchers have paid considerable attention to the role of beliefs in shaping decisions about curriculum, instruction, and assessment. For example, research indicates that self-efficacy beliefs (Tschannen-Moran, Woolfolk-Hoy, & Hoy, 1998), and attribution beliefs regarding student performance (Borko & Shavelson, 1978) influence these facets of teaching practice. A particularly rich area of inquiry is mathematics education, where researchers have found that teachers’ implementation of math curriculum is strongly influenced by teachers’ beliefs (Ball, 1988; Borko, Eisenhart, Brown, Underhill, Jones, & Agard, 1992). In particular, teacher beliefs about student learning may impact their subsequent decisions about topics ranging from grouping students into ability-based groups (Shavelson & Borko, 1979 to judgments regarding students’ symbolic and verbal reasoning abilities (Nathan & Koedinger, 2000).

Research in this area is strongly grounded in cognitive psychology and tends to view instructional decision-making as a complex process involving various schemata, or cognitive structures stored in long-term memory, that are activated in particular situations (Shavelson &

Stern, 1981). One of the schemata thought to influence teaching practice is pedagogical beliefs, particularly in how they influence the specification of problem-solving situations and subsequent strategies in unstructured or ill-defined situations such as those that are commonly encountered in the classroom. Nespor (1987) described this process in terms of the nature of perception and how individuals unconsciously bring to bear various cognitive resources or “tools” when perceiving new situations or information, including facts, memories, decision heuristics, or whichever resources are available. In cognitive science this process of drawing upon representations of situations, initial and desired goal states related to a given situation, and possible actions or strategies for satisfying these goals is known as searching through a “problem space” (Newell & Simon, 1972). Beliefs are thought to play an important role in shaping these problem spaces because they can be held in memory for long periods, be easily retrieved due to their association with notable episodes, and have an affective saliency that guides action (Abelson, 1979; Nespor, 1987). In addition, evidence indicates that beliefs can shape perceptions about which features of a problem will be noticed and responded to as well as guiding the selection of particular problem-solving strategies (Bandura, 1977).

In order to examine the specific processes whereby teacher cognition influences specific instructional decisions, Alan Schoenfeld (2000) developed a research program focused on discerning “precisely why teachers make particular choices at each point of instruction (p. 2).” In his model Schoenfeld pays considerable attention to the interactions among three distinct types of schemata (i.e., knowledge, goals, and beliefs) within specific environmental contexts, and how they influence lesson plan development and classroom behaviors. In particular, Schoenfeld emphasizes the importance of accounting for the role of different organizational and classroom contexts. In a similar fashion, Greeno (1998) emphasized the role of perception and how teachers can become attuned to particular constraints and affordances in their environment, which over time lead to patterns of social interactions and instructional behaviors (see also Lee & Porter, 1990). This view of cognitive activity as situated within specific organizational contexts holds considerable promise for the study of faculty teaching in general, and the role of beliefs in shaping planning and teaching decisions in particular.

Theoretical Framework

In this study I draw on the situative perspective as articulated by James Greeno (1998) to investigate the processes that characterize faculty decision-making. A fundamental premise of the situative approach is that the individual agent, and his/her own cognitive activity and learning processes, take place in relation to the task environment in which the agent functions. Put another way, advocates of situated cognition emphasize that cognition takes place in the context of task-relevant inputs and outputs, such as environmental features being perceived by the agent and subsequent actions that then influencing the situation itself (Wilson, 2002). This approach is particularly salient for educational research given that the problem spaces relevant to teaching situations are unstable and poorly defined. Instead, features of the problem space “emerge” during the activity of planning a lesson or interacting with students in the classroom. As a result, Greeno (1998) argues that researchers should focus on the processes whereby problem spaces are constructed and modified. In this study I focus on the role of pedagogical beliefs in this process, given prior evidence that teachers' beliefs will frame how new situations or problems are perceived and conceptualized (Fives & Buehl, 2012; Nespor, 1987).

Another important feature that shapes this process is how an individual perceives his or her sociocultural and organizational environment to pose constraints or affordances to their actions. When encountering people, objects, and organizational processes, individuals will perceive these phenomena to have particular properties and possibilities or affordances for interaction (Norman, 1988). For example, some organizational roles such as "assistant professor" will carry with them particular assumptions regarding time allocation, teaching-related activities, and so on. According to this view, when engaged in planning and instructional activities, faculty will "read" their environments and determine how local policies, procedures and the curriculum affords or constrains particular pedagogical choices (Hora, 2012; Lattuca & Stark, 2009). This understanding is particularly important because faculty do not go about their daily work in a vacuum, but are "embedded in an organizational matrix" of influences including their discipline, profession and institution, thus necessitating a view of practice that accounts for contextual factors and how they are perceived by faculty in relation to their teaching practice (Umbach, 2007, p.263).

Finally, a situative view also has implications for the study of classroom teaching itself. The dominant view of teaching, as solely the overt teaching methods (e.g., lecturing) used by instructors in the classroom, is based on the notion that teaching is reducible to a decontextualized, single behavior of an individual. Instead, activity itself can be thought of in broader terms of the context itself in which activity occurs (Cole, 1996). In this way, classroom teaching itself is seen as a multifaceted practice that encompasses the teacher, students, and features of the instructional task (Cohen & Ball, 1999).

Methods

The design for the study is a qualitative case study, which is an intensive analysis of a single bounded unit (e.g., an incident or an organization) (Yin, 2008). The case focuses on 56 math and science instructors at three large research universities who taught undergraduate courses in the spring of 2010. After examining the beliefs and their underlying dimensionality for all 56 faculty, I then conducted micro-level case studies of two individuals in order to examine the relationship between beliefs and teaching practices in greater detail. The study also adopts a concurrent mixed design in drawing on both interviews and classroom observations equally during the data analysis phase (Tashakkori & Teddlie, 2002).

Research Sites and Sampling Procedures

The research sites for this study were three public research institutions with similar numbers of undergraduate students and active pedagogical reform initiatives underway at the time of data collection. Research universities were selected due to the large number of undergraduate students trained in the science, technology, engineering, and mathematics (STEM) disciplines at these institutions. Five STEM disciplines were targeted for study based on the presence of existing pedagogical reform initiatives: math, physics, chemistry, biology and geology. The course component of interest for this study was the classroom component (i.e., the lecture) instead of discussion or laboratory sessions. The sampling frame for the study included 263 individuals listed in the spring 2010 timetable as the instructor of record for undergraduate courses. Individuals were contacted up to two times via e-mail for participation in the study, and 57 faculty (22% of the initial sample frame) participated in the study (see Table 1). While 57 faculty participated in this study, one respondent requested that his interview not be recorded. Thus, the total sample for the interview component of the study was 56.

Table 1
Description of sample

	n	Percentage
Sex		
Female	22	39%
Male	35	61%
Institution		
A	18	32%
B	21	46%
C	18	32%
Discipline		
Math	18	32%
Physics	11	19%
Chemistry	9	16%
Biology	11	19%
Earth/space science	8	14%
Level of course		
Lower division	39	68%
Upper division	18	32%
Size of Course		
50 or less	10	18%
51-100	18	31%
101-150	9	16%
151 or more	20	35%
Position type		
Lecturer/Instructor (non tenure-track)	29	51%
Assistant Professor	6	11%
Associate Professor	4	7%
Professor	18	31%

Limitations to the study include self-selection bias and the lack of data regarding tacit or subconscious beliefs of respondents. Thus, study respondents likely represent a nonrepresentative sampling of faculty within the study institutions, especially in regards to their interests in teaching and learning. Therefore, all conclusions should be considered in light of the fact that respondents self-selected into the study. Another limitation to the study is that no data regarding the subconscious or implicit beliefs of respondents are elicited. This is due to the descriptive and nonexperimental design of the study. In the future, researchers should consider using techniques from experimental psychology such as priming to examine the role that implicit beliefs and/or automaticity plays in instructional practice (e.g., Bargh, 2005).

Data Collection

The data collected in this study includes an interview and two classroom observations with each respondent. A team of three researchers conducted all data collection activities. One researcher observed two class periods of each respondent, with interviews typically taking place immediately prior to or after an observed class. The interview protocol for this study utilized a semistructured approach, where all respondents were encouraged to explore new ideas tangential to the questions posed to them (Spradley, 1979). Thus, while each respondent was asked all of the questions in the protocol, the length and depth of answers varied considerably. The interviews lasted approximately 45 minutes. Questions in the protocol salient to this study include: (1) What is your view about how people best learn key concepts in your field at the undergraduate level? (2) Is this view evident in how you plan and teach this course? And, (3) What factors did you take into account as you planned the course? The interviews were conducted in respondents' offices and the audio recordings were later transcribed.

In addition to the interviews, each respondent was observed for two full class periods using the Teaching Dimensions Observation Protocol (TDOP). The TDOP was developed to code the participating instructors' use of teaching methods (e.g., lecture, small group work), cognitive engagements (e.g., memorization, problem solving, creating), and instructional technologies (e.g., clickers, chalkboard) at 5-minute intervals throughout the duration of each observed class period. Importantly, TDOP codes were not designed to correspond to any particular belief types but instead were designed to capture multiple dimensions of instructional practice. Prior to data collection the three researchers participated in an extensive 3-day training process. In order to establish interrater reliability, the analysts coded three videotaped undergraduate classes. The following are the results of the inter-rater reliability using Cohen's Kappa for each pair of raters (averaged across the three categories): Analyst 1/Analyst 2 (.699), Analyst 1/Analyst 3 (.741), Analyst 2/Analyst 3 (.713).[1]

[1] See Hora & Ferrare (in press) for detailed information about the development of the TDOP.

Data Analysis

The data for this study were analyzed in two stages. First, all 56 interview transcripts were analyzed to identify belief types and any underlying dimensionality to these beliefs. Second, the planning and classroom practices of two instructors were analyzed to investigate the specific mechanisms by which beliefs influenced (or not) their teaching practices.

Stage 1: Identifying belief types and their dimensionality. The analysis for this stage of the study followed the verbal analysis technique of Chi (1997), which is a structured approach to discerning the structure of cognition through analyses of verbal data. The first step in the analysis involved segmenting the data into manageable units using a structured coding scheme. The coding scheme was created by first using an open-coding process, followed by the constant comparative method which entailed comparing successive instances of a newly created code to previous instances in order to confirm or alter the code (Glaser & Strauss, 1967). For this phase of the analysis I worked with another researcher, and we independently developed our own code lists and then met to revise and refine a final coding scheme. Examples of codes included "beliefs about student learning" and "course syllabi." After applying the coding scheme to five transcripts, interrater reliability was assessed by calculating the percentage of agreement between the analysts in applying the codes (89%). The analysts then applied the coding scheme to all 56 transcripts using NVivo® qualitative data analysis software, which resulted in an extensive library of coded text. Then, I took all text fragments coded as "beliefs about student learning" and analyzed them using the open coding and the constant comparative methods, which resulted in the identification of 15 unique types of beliefs. As a reliability check another researcher reviewed 25% of the raw data coded as "beliefs about student learning" and confirmed the initial finding of 15 belief types.

Next, in order to examine the degree to which the 15 beliefs exhibited dissimilarity or similarity (i.e., underlying dimensionality), I used a combination of data reduction and inductive techniques to analyze the interview data. First, a cluster analysis was performed. Cluster analysis is a nonstatistical procedure for partitioning objects into groups based on (dis)similarity as measured through a distance matrix (in this case binary squared Euclidian distance). The matrix used in this analysis included respondents as rows and belief types as columns, with a "1" indicating the presence of a belief type and "0" indicating its absence. In this analysis I used an agglomerative form of hierarchical clustering, and the particular clustering algorithm used in this analysis is referred to as Ward[1]s Method. Additional analyses such as the "furthest neighbor" method of clustering were conducted supported these results. Next, as a complement to the cluster analysis I used a nonmetric multidimensional scaling (MDS) procedure to analyze the data. Instead of locating belief types into mutually exclusive groups as is done in cluster analysis, multidimensional scaling graphically represents the similarity (or dissimilarity) between themes as distances in a two-dimensional space. In this analysis I used Euclidean distance to identify theme proximities. Then, in order to interpret the meaning behind these results I organized the original text fragments coded as "views of learning" into the two groups suggested by the cluster and MDS analyses, and examined the data to identify whether or not each group varied according to a discernible theme. A new set of open codes was derived while reviewing these data and ultimately a single theme emerged that best described the grouping of the belief types.

Stage 2: Case studies of individual instructors. The next stage of the analysis entailed conducting in-depth case studies of two instructors. Given widespread interest in encouraging "interactive" teaching techniques, and whether or not beliefs and/or situational constraints are related to the use of these techniques, two instructors who utilized interactive approaches based on their observation data were identified. While no objective standard exists to determine the degree of an instructor's "interactivity," I used three criteria from the literature including a high-degree of question asking (Pedrosa-de-Jesus, da Silva Lopes, Moreira & Watts, 2012), diverse types of student cognitive engagements in the classroom (Blumenfeld, Kempler, & Krajcik, 2006), and the pacing of lessons that avoids extensive stretches of the same activity (Burns, 1985). Once two individuals meeting the criteria for inclusion were identified, their interview transcripts were analyzed using thematic network analysis. Thematic network analysis is a structured approach for identifying relationships between concepts in a graphic and time-ordered fashion (Miles & Huberman, 1994). Each respondent's transcript was inductively analyzed to identify the following elements of decision-making: beliefs about student learning, instructional goals (i.e., explicit goal statements), prior experiences (i.e., explicit references to past teaching and/or learning experiences), perceived affordances (i.e., how the context constrained or afforded teaching), and lesson plans (i.e., explicit plans for the observed class). Then, each transcript was analyzed to identify statements regarding relationships among these elements.

Results

In this section I report the results regarding the beliefs that faculty have for how undergraduate students learn in their disciplines, the underlying dimensionality of these beliefs, and case studies of two faculty that examines the relationship among cognition, context, and teaching.

Belief Types

The analysis of interview data resulted in the identification of 15 distinct themes for student learning (See Table 2). The range of reported beliefs per person varied from zero references to seven references. Each belief type is briefly described in the following section.

Table 2
Faculty beliefs about student learning (n=56)

	Belief Type	Number of References	Belief Description
1	Practice and perseverance	27	Learning comes through prolonged effort on solving conceptual and computational problems by self.
2	Variability	20	All people learn differently (e.g., visual, auditory, hands-on, etc.).
3	Hands-on/ Application	18	Learning is best facilitated through active, hands-on engagement with the material (e.g., labs, field-work).
4	Articulating	16	Students learn best when vocally articulating their own thoughts, ideas, and problem-solving processes to others.
5	Not in the classroom	16	The classroom (i.e., the lecture) is not the best venue for learning.
6	Visualizations	13	Students learn effectively when material is put into visual or other physical form.
7	Active construction	12	Students must actively develop their own understandings of the material.
8	Connection to experience	10	Learning is facilitated when course material is explicitly linked to students' own experiences.
9	Scaffolding	8	Learning is facilitated when course topics are presented in a sequential fashion from least to most difficult.
10	Examples	5	Students learn from concrete examples and illustrations of course material.
11	Explication	5	Learning is facilitated through the clear explanation of topics or problems.
12	Repetition	4	Students learn through repeated exposure to a topic or idea.
13	Osmosis	3	Students learn by being in the presence of an expert (i.e., an academic).
14	Memorizing	2	Learning is accomplished through memorizing facts or computational rules.
15	Individualized instruction	2	Learning is facilitated through one-on-one interaction with an instructor.

Practice and perseverance. 27 respondents reported the belief that student learning is best achieved when the student studies and practices problem-solving diligently on their own time. A core feature of this belief is that learning occurs over time and through sustained engagement with the material. The level of engagement that faculty felt was a requirement for learning was very high. As one respondent stated, students "will not learn until they do it a thousand times." Interestingly, several faculty described this belief in physical or even violent terms, such as "banging one's head against the table," "mental weight lifting," and "grinding away at it," which underscores the view of learning as one requiring a significant investment of time and energy. Finally, several respondents described their beliefs about practice and perseverance in terms of homework assignments. The class then becomes a staging ground for introducing problems that students then take home (or to the lab) to probe more deeply.

Variability. The next most regularly cited belief was that the fundamental nature of learning varies from person to person (20 respondents). One respondent characterized this belief as "the eyes, ears, and handwriting" theory of learning, such that some people are auditory learners while others learn most effectively through visual or text-based methods. As such, no single type of instruction or learning milieu is adequate for all students, but instead, different people will gravitate to the type of learning they find most effective. One of the implications of this belief is the subsequent attempt by some faculty to provide what is known as differentiated instruction, where different avenues for learning the material are provided to students based on their aptitude and learning preferences. For example, one chemist in the study stated that given the range of student learning styles, he deliberately planned his classes to include lectures, hands-on exercises, readings, and web-based modules.

Hands-on/application. 18 respondents reported the belief that learning takes place when students are actively engaged with the material in a hands-on manner. This type of learning was frequently associated with venues such as laboratories or fieldwork sites. In this case, learning does not occur through the passive reception of information but through the active involvement with the subject matter. For example, a physics faculty member stated that students should take the principles of physics gleaned from their classes or readings and "apply them to real things."

Articulating. 16 respondents expressed the belief that learning occurs when students are forced to articulate their own understanding of the material to their peers or the instructors. That is, an especially effective way to learn something is to be forced to teach it, because through the act of verbalizing one's level of comprehension for a given topic it becomes clear to the audience whether or not the interlocutor genuinely understands the material. Additionally, through the act of expressing their ideas to peers or instructors, students put themselves in a position to receive valuable feedback in the form of confirmation or critique.

Not in the classroom. 16 respondents reported that learning best takes place outside of the classroom. In other words, faculty expressing this belief felt that of all possible learning environments (e.g., classrooms, laboratories, field-work, etc.) the classroom format, particularly large "lecture" style classes, was the least amenable to facilitating student learning. In several cases, particularly among faculty from biology and geology, respondents stated that students only really understand how to "do science" when they design studies or collect and analyze data in the field. Thus, the classroom is viewed as a venue in which basic principle of a discipline are conveyed, but only as one component of a student's overall educational experience.

Visualizations. 13 respondents expressed the belief that students learn most effectively when the content is put into visual or other physical form. This belief is based on the assumption that learning abstract topics is harder for students than learning through the physical manifestation of course material. For several faculty this simply entailed projecting PowerPoint slides of images that illustrated the material (e.g., RNA sequences, volcanic eruptions), whereas others used more complex demonstrations or models. For example, one chemistry professor stated that “chemistry is a colorful world of molecules” that could be shared with students through physical models or drawings of molecular structures on the chalkboard.

Active construction. 12 respondents reported the belief that learning is dependent on students actively constructing their own unique understanding of course material. In several cases the term “construct” was used to describe the learning process, and three faculty specifically referenced constructivist learning theories. An important idea underpinning these references was that retention and comprehension is enhanced when students come to appreciate course material on their own terms. That is, students do not rely on the instructor’s formulation of a concept or the textbook, but as one chemistry faculty noted, “successful students reformulate it (course material) in their own terms.”

Connection to experience. 10 respondents expressed the belief that students learn best when the connection between the material and their own lives is made explicit. Five respondents used the word “motivate” to explain this phenomenon, as they felt that students should not be expected to be excited about the material on their own, and that instructors had to clearly explain why the topic was relevant to their lives and future careers. One chemistry faculty teaching a course with pre-med students felt that the relevance of chemistry to health science was often unclear, so he included topics such as the history of penicillin to make the connection explicit.

Scaffolding. Eight respondents expressed the belief that student learning is best achieved when instructors effectively sequence course material. This scaffolding of material can take place in a variety of ways, from introducing basic concepts first followed by more complex material, or by providing concrete illustrations before delving into more abstract principles.

Examples. Five respondents expressed the belief that students best learn when given content-rich and real-world examples of course material. That is, providing abstract principles or theorems with little or no concrete illustrations regarding how they either can be used to solve actual problems, or how they appear in the natural world, does not adequately engage students or provide them with ways to envision applying these ideas in their own problem-solving. These examples can take many forms, including anecdotes, analogies, or multimedia.

Explication. Five respondents reported the belief that students require explicit, step-by-step descriptions of course material, particularly at the early undergraduate level. For these respondents a key antecedent to learning is the instructor clearly explaining the material. For example, one math faculty answered the question regarding beliefs about student learning with the short reply, “You explain the principles and then they have to practice it – that’s it.”

Repetition. Four respondents stated that effective learning requires repetition, particularly for students with limited background or aptitude. That is, by reviewing topics regularly and focusing on particularly important or challenging concepts several times, instructors create an environment in which students can learn effectively.

Osmosis. Three respondents expressed the belief that students learn by being exposed to high-quality researchers. As one biology faculty stated, all students should take courses from active researchers who can share cutting-edge ideas with their classes, because they have access to information and opportunities that other instructors do not.

Memorizing. Two respondents reported the belief that memorization was a key facet of learning, particularly in math and science. As one biology faculty stated, biology is a “foreign language” with a substantial amount of new terms and concepts. Thus, a key component of learning is students memorizing this new language.

Individualized instruction. Finally, two respondents expressed the belief that learning best occurs in one-on-one situations where the faculty member can provide individualized instruction. In venues such as office hours, the instructor can help students get past “cognitive humps” and assist them in recognizing where they are encountering challenges with the material.

Dimensionality of Beliefs

As previously noted, several researchers investigating the psychological antecedents to teaching argue that they exist on a continuum from teacher-centered/content-oriented to a student-centered/learning-oriented (e.g., Kember 1997; Samuelowicz & Bain, 2001). Given these findings in the literature, as well as the fact that the belief types appeared to refer to distinct phenomena (e.g., student learning, classroom organization, etc.), I used exploratory data reduction and inductive analytic techniques to examine whether or not an underlying dimensionality could be discerned. First, a cluster analysis was conducted (see Figure 1).

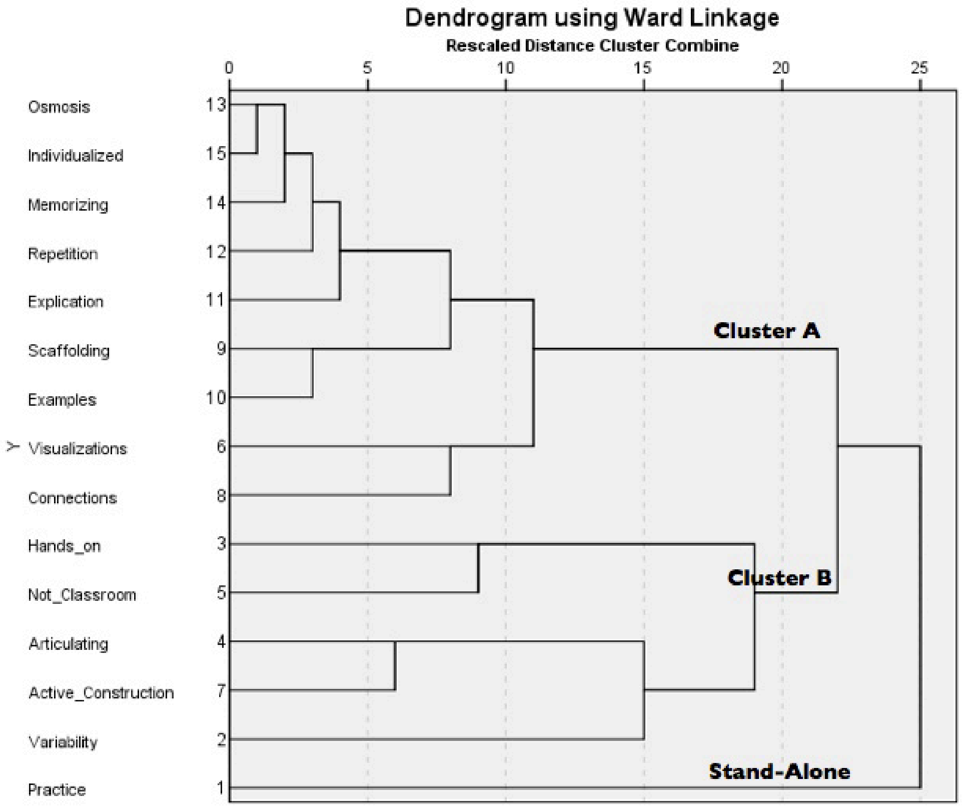

***Figure 1*.Cluster analysis dendrogram of belief types**

The resulting dendrogram indicates that the 15 beliefs fall into two clusters: The first cluster (hereafter Cluster A) includes the following beliefs about student learning: osmosis (#13), individualized instruction (#15), memorizing (#14), repetition (#12), explication (#11), scaffolding (#9), examples (#10), visualizations (#6), and connection to experience (#8). The second cluster (hereafter Cluster B) includes the following beliefs about student learning: hands on/application (#3), not in the classroom (#5), articulating (#4), active construction (#7), and variability (#2). The most highly reported belief of practice and perseverance (#1) did not cluster with the other groups, which suggests that either hierarchical cluster analysis is not a necessarily good fit for these data, or that this belief was sufficiently dissimilar from the others so as not to be included in the two main clusters. Second, I conducted a MDS analysis that depicts the proximities between pairs of objects as distances in low dimensional spaces. The arrangement of the belief types in the MDS graphs was similar to the clusters identified in the cluster analysis. The large group in the center of the graph overlaps with beliefs within Cluster A (e.g., osmosis (#13), individualized instruction (#15), memorizing (#14), repetition (#12), explication (#11), scaffolding (#9), and examples (#10). A more diffuse grouping along the bottom of the graph includes beliefs from Cluster B (e.g., hands on/application (#3), not in the classroom (#5), articulating (#4), and active construction (#7). Both variability (#2) and practice and perseverance (#1) are located in spaces distant from these two groups (see Figure 2), which suggests that these beliefs are dissimilar from those beliefs in Clusters A and B.

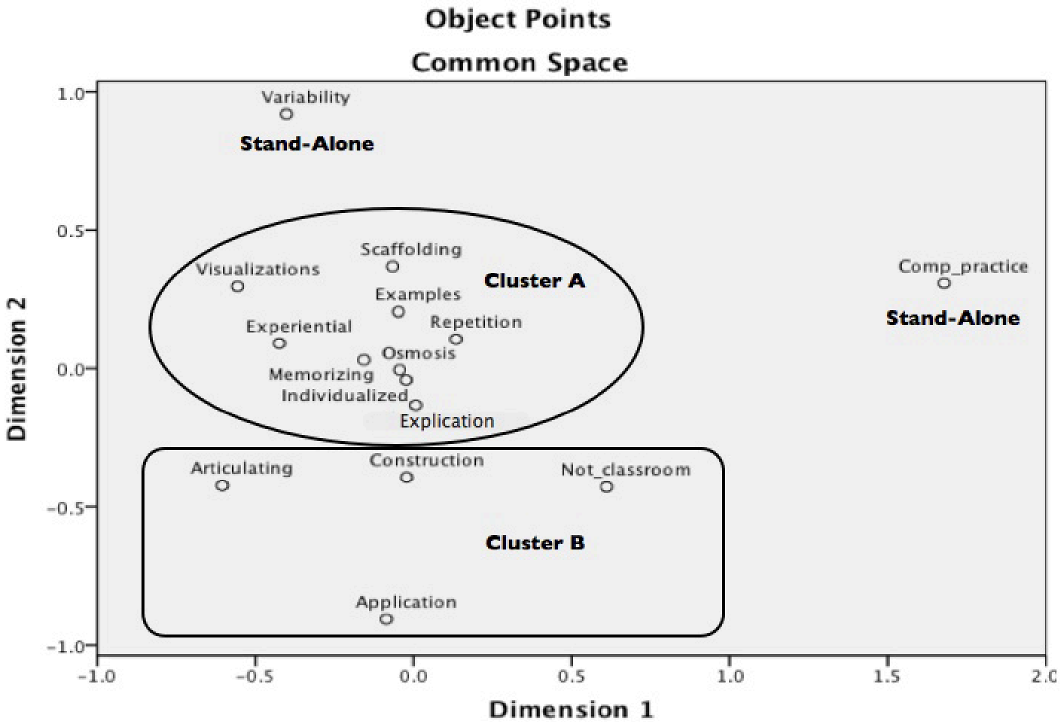

Figure 2. Multidimensional scaling graph of the belief types

Since neither data reduction technique provides any information about the nature of the results, a subsequent interpretive step is necessary. To do this I re-examined the interview data which resulted in the identification of a single theme that best explained the variation between the two clusters: the agent who is seen as playing the principal role in constructing knowledge and meaning—the teacher or the student. That is, these beliefs vary based on who respondents view as the individual who should be the primary agent who makes sense of the material and is thus responsible for learning. The student is always the individual doing the actual learning, and the instructor is always visible in the instructional process, but the clusters suggest differences in how faculty view their role in the learning process.

In Cluster A, it is the teacher that constructs meaning and presents it through a variety of methods: students learn by being in their mere presence (osmosis), one-on-one instruction (individualized), by memorizing facts that the teacher presents (memorizing), clearly explaining the material (explication), and so on. Thus, learning takes place largely through student absorption or internalization of knowledge that the teacher has constructed and presented. In Cluster B it is the student who constructs meaning. The student engages in hands-on experiences of his/her own (hands on/application), learns on their own outside of the classroom (not in the classroom), vocalizes their own thoughts and ideas (articulating), and so on. Thus, learning occurs primarily through the student's own construction of knowledge.

In the case of the two most highly cited beliefs (i.e., practice and perseverance belief and variability), I suggest that these beliefs cannot be interpreted in relation to this dimension of student- or teacher-centered knowledge construction. Instead, these beliefs represent their own unique set of views about teaching and learning that do not necessarily pertain to which agent is constructing meaning. That is, they represent stand-alone beliefs that exist outside of this dimension, which represents a departure from prior research that characterized all faculty beliefs according to a student- or teacher-centered dimensionality. Further contradicting the literature, these data suggest that faculty cannot be characterized entirely as having either a student-centered or a teacher-centered set of beliefs about learning. This is because 66% of the respondents in the study (37) reported beliefs that were not limited solely to Cluster A, Cluster B, or either of the stand-alone beliefs (See Table 3). While 19 individuals did report beliefs that lay solely in one of these categories, a majority reported beliefs that cut across these categories.

Table 3
Distribution of Respondents Reporting Beliefs in Single Clusters or Across Clusters (n=56)

	# of Respondents
Mixed (across belief types)	37
Only Cluster A	3
Only Cluster B	9
Only Practice/Perseverance	4
Only Variability	3

These results suggest that the dimensionality underlying these beliefs is not an either-or proposition where individual faculty must be assigned to a single "type" of belief (Postareff & Lindblom-Ylanne, 2008). Instead, individuals may hold a variety of beliefs along a single dimension comprised of two poles representing student- and teacher-centered beliefs, or that there are actually two (or more) dimensions whereupon individuals may hold strong or weak beliefs on different dimensions simultaneously (Eley, 2006).

Case Studies: Examining the Role of Beliefs in Instructional Practice

The third research question motivating this study focuses on the role that beliefs play in course planning and classroom instruction. To answer this question, case studies of two faculty are presented, both of whom exhibited interactive teaching behaviors in the observed classes.

Case Study 1: Dr. Garcia (Department of Physics)

The first case describes the teaching practices of Dr. Garcia (a pseudonym), who is a full-time lecturer in the physics department at Institution A. At the time of data collection Dr. Garcia was teaching the third quarter in the calculus-based introductory physics series. In response to the question regarding views about student learning, Dr. Garcia responded as follows:

> My view is that it (student learning) is incredibly varied. As many people as there are, there are probably that many different ways that humans attain knowledge. But on the other hand, there may be a best way overall and I would say that that is personal perseverance. They (the students) must decide that they have to really work through it. Also I think for many students the breakthrough is when they realize they need to take physics and apply it to things. If they understand how a car or a fluorescent light works, that is when they have started to really learn it.

In this response Dr. Garcia expressed three different beliefs about student learning: variability (#2), practice and perseverance (#1), and hands-on/applications (#3). In addition, Dr. Garcia later added that his classes were "definitely not a key to them understanding," which is the belief that learning takes place outside of the classroom (#5). Additionally, he noted that learning is easier when "you can see it," which refers to visualizations (#6). In expressing such a range of views, Dr. Garcia is one of the 37 faculty in this study whose beliefs did not fall solely within one of the two identified clusters or in the underlying belief of practice and perseverance.

Next, Dr. Garcia was asked to what degree these beliefs were evident in his teaching, and he noted that the size of the class acts as a substantial constraint to this teaching. This observation was interesting in that no clear explanation linking beliefs and teaching was offered, though later in the interview Dr. Garcia alluded to the fact that it was challenging to do hands-on activities in large lecture halls. Thus, it appears that class size is perceived to be an impediment to the hands-on/applications belief about student learning (#3). Indeed, he also stated that given the class size he attempts to "get them to interact" through regularly asking questions. Dr. Garcia also reported that several other factors influences how he plans and teaches his classes. First, he expressed a goal for the class that he directly linked to his classroom behaviors—that of having the students be directly involved and engaged during the class. Second, Dr. Garcia noted that his prior experiences as a student regarding which topics he found confusing, and his experiences as an instructor regarding what has worked (and not worked) in previous classes both informed his current practice. Third, Dr. Garcia perceived that several factors within his organizational environment represented constraints and affordances to his teaching. The curriculum and syllabus demarcate the type and sequencing of content in the course, such that Dr. Garcia felt that he had little say regarding what material will be included in the course. He also felt that the type of students within his course (i.e., engineering majors) influenced how he taught. Thus, beliefs, instructional goals, prior experience, and perceived affordances all play a role in influencing how this instructor plans his classes and approaches his classroom teaching.

For the class being observed, Dr. Garcia stated that he planned to apply the harmonic oscillator equation and then use these techniques to find the pendulum equation for the pendulum at low angles. The specific teaching methods that he planned to use to discuss these topics included asking several questions and using clicker questions, demonstrations, and the chalkboard for writing out equations. Importantly, Dr. Garcia observed that his decision to use demonstrations was influenced by the presence of a designated staff person who managed a large selection of equipment, and assisted each instructor in setting them up before class and taking them down after class. In the observed class, Dr. Garcia began by outlining three main goals for the day's class: to discuss harmonic oscillators, energy, and the simple pendulum equation. He then discussed Hooke's Law while lecturing at the chalkboard, and demonstrated the principle using a large pendulum hanging from the ceiling. The remainder of the class followed this pattern of teaching behaviors: lecturing at the chalkboard (observed in 90% of all 5-minute intervals), demonstration (70%), and posing display questions seeking new information (80%). A graphic depiction of the data described in this case study, and two thematic networks that establish either relationships between beliefs and teaching practice are depicted in Figure 3.

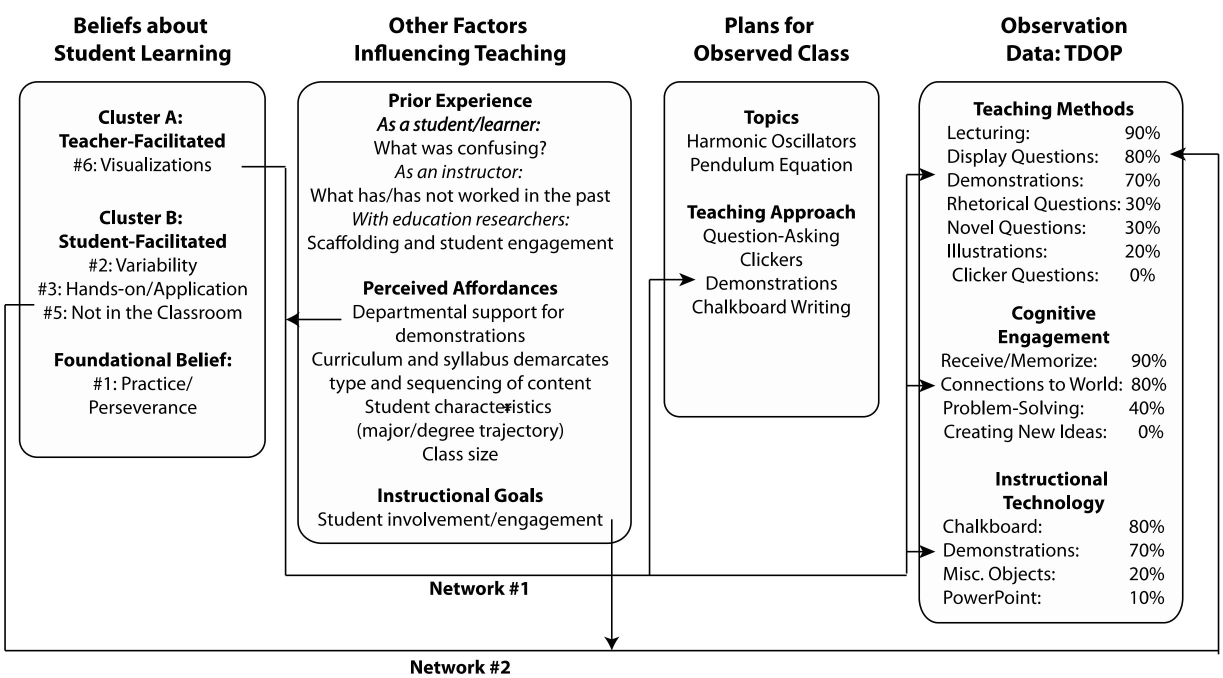

***Figure 3.* Thematic Network Analysis of Dr. Garcia's Planning and Teaching Process**

Thematic network #1 represents the relationship among the visualizations belief (#6), the perceived affordance related to departmental support for demonstrations, and the use of demonstrations as a teaching method, instructional technology (i.e., demonstration equipment), and as a way to cognitively engage students in the classroom. This network suggests that the belief interacted with a perceived affordance to contribute to the use of demonstrations during class. Thematic network #2 represents the relationship among the hands-on/application (#3) belief, the instructional goal of directly involving students in the class, and the observed teaching practices of posing questions to students during the class period. This network suggests that the belief interacted with an instructional goal in a way that contributed to the regular posing of questions during the class.

While Dr. Garcia reported particular beliefs (e.g., visualizations) that could be interpreted as being related to specific behaviors (e.g., demonstrations), no evidence exists that supports a causal relationship between beliefs and teaching practice. Instead, I suggest that the data are more appropriately interpreted in light of prior research that indicates beliefs play an important role in defining tasks and organizing information (Nespor, 1987; Pajares, 1992). A key aspect of this "framing" process is that beliefs act to define the parameters of new tasks or problem, such that a task such as teaching the harmonic oscillator equation itself can be seen in a variety of ways (e.g., disseminating information to passive students, or actively engaging students in constructing their own understanding). Thus, the beliefs that Dr. Garcia articulated can define the problem space in which he approached this task (McAlpine et al., 2006). In particular, his beliefs that students must have a "breakthrough" and actually "apply (physics) to things" (i.e., the hands-on/application belief) suggests that Dr. Garcia views the problem of learning in this instance as one contingent upon having students be placed in positions where they can have personal interactions with the material on their own terms. Such framing of the problem of teaching could then be associated with particular instructional strategies such as periodic questioning. However, the data do indicate that factors such as goals and perceived affordances exert a considerable influence on Dr. Garcia's decision-making, which is consistent with prior research (e.g., Schoenfeld, 2000). Thus, beliefs appear to play an important, yet by no means an exclusive, role in shaping the teaching behaviors of this instructor.

Case Study 2: Dr. Weston (Biology)

The second case study features Dr. Weston (a pseudonym), who was a full-time lecturer in the biology department. She had been at Institution B for over 10 years, and was teaching a junior-senior level capstone course in molecular cell and developmental biology. In response to the question about student learning, Dr. Weston stated that:

> Different people learn key concepts differently, and that some students prefer to listen. So I guess there's two answers to that question: one is that I think that students have clear preferences for learning styles, and even when you try to be active in your teaching approach some students will only learn in the way that they find most comfortable for themselves, and they will refuse to participate in things they are not comfortable with.

This statement clearly indicates that Dr. Weston held the variability belief (#2) about student learning. Interestingly, Dr. Weston then characterized this view as a "student perspective" in that it placed the student and their preferences for learning at the center of considerations about instruction. In contrast, she felt that the "teacher's perspective" emphasized the instructors' considerations for the material in favor of thoughts about students' abilities or learning styles. Dr. Weston also characterized the teacher's perspective as the "information dissemination view" where teaching is seen as a matter of conveying information from the textbook. Thus, within Dr. Weston's beliefs about student learning were embedded related beliefs about instruction. In further statements, Dr. Weston stated that she personally leaned towards the student perspective, and that students learn best by being actively engaged in the material (hands-on/application #3), actively constructing their own understanding of the material (#7), and students' actively articulating (#4) their own ideas to instructors and/or peers. In expressing these beliefs she stated that while independent study was important, having a dynamic classroom environment was an indispensable component to learning. Dr. Weston also reported beliefs regarding learning occurring outside of the classroom (#5). Thus, her beliefs all lie within Cluster B.

For the observed class, Dr. Weston planned on discussing synapse formation and eye anatomy. In terms of teaching methods, she planned on lecturing, which she apologetically justified by saying that "I still do transmit information" and that "I have tried to do away with it entirely and it never just quite works." This observation indicates that lecturing, which is viewed by some researchers as an unsophisticated teaching approach that should be avoided, was seen by Dr. Weston as an indispensible part of teaching. As she noted, "there's always a time in the class where it seems like I just have to say a few things or nobody will have a clue where to get started." So she planned to lecture as an introduction to the material, to "frame" the class period, and to introduce new terms. Dr. Weston also planned on using clicker questions as a precursor to small group discussions, PowerPoint slides, and to pose several questions to students.

Dr. Weston then noted that a significant constraint shaping her decision-making process is time, and whether she'd had a chance to figure out "the right sequence of things that I think will trigger them to really learn." She also observed that her prior experience as an instructor, when she engaged in "pure" lecturing, had led her to realize that she disliked this way of teaching, and that it likely was not very effective. This sentiment coincided with the growth of a community of faculty engaged in science education on campus, which provided a rich resource of teaching tips and materials, and a supportive network of other like-minded educators that was considered by Dr. Weston to be important given the research-oriented mission of her institution. In the observed class Dr. Weston exhibited a variety of teaching methods including lecturing, question-asking, small group work, case studies, and illustrations (See Figure 4).

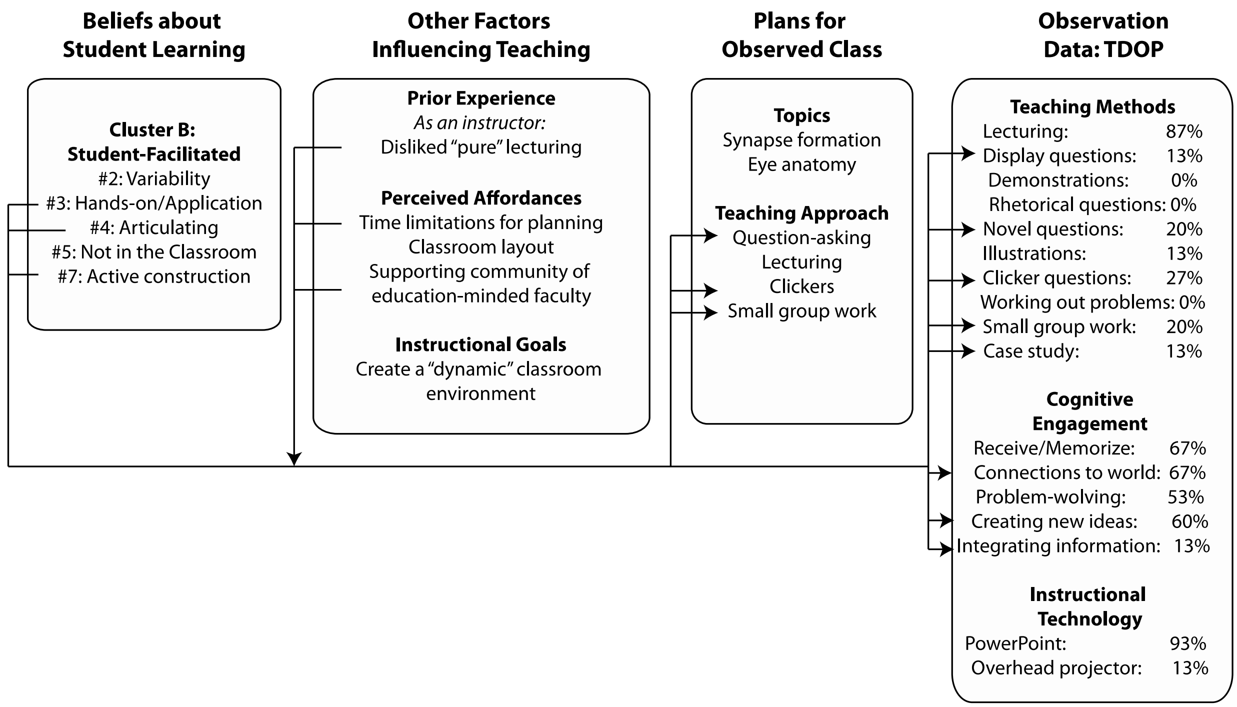

***Figure 4*. Thematic Network Analysis of Dr. Weston's Planning and Teaching Process**

Thematic network #1 represents the relationship among three beliefs, Dr. Weston's prior experience as a "pure" lecturer, and perceived affordances related to time constraints and supportive colleagues that together influenced her subsequent teaching behaviors. All of Dr. Weston's beliefs fell within Cluster B, and several of her planned and observed practices were consistent with such a view. However, the evidence does not indicate that these beliefs had a unilateral and causal relationship to these practices as is suggested in the literature (Gibbs & Coffey, 2004; Trigwell, Prosser, & Waterhouse, 1999). Instead, Dr. Weston's prior experiences and perceived affordances also played an important role that supports the notion that a variety of cognitive resources are brought to bear on problem-solving (Schoenfeld, 2000).

Finally, the substantial use of lecturing during the observed class (87% of all 5-minute intervals) is notable given the dominance of student-centered beliefs expressed by Dr. Weston. However, she provides a clear rationale regarding the use of this pedagogical technique, that at some point an instructor just has "to say a few things or nobody will have a clue where to get started." The co-existence of a high degree of lecturing and high proportions of interactive teaching techniques and a range of student cognitive engagement suggests that it may not be the case that faculty who value students' construction of meaning do not lecture, and that lecturing does not automatically translate into unsatisfactory or inadequately engaging instruction.

Discussion

In this section I elaborate on the results presented in this paper and explore possible implications of these findings for instructional improvement at the undergraduate level.

Types of Beliefs

The data reported in this paper regarding the 15 distinct types of beliefs for student learning represents the first empirical evidence on this critical topic since the early studies of Prosser, Trigwell, and Taylor (1996). While prior research found five types of beliefs that varied according to the nature of learning (e.g., accumulating information) and the source of validation for learning (e.g., internal or external), the findings reported here indicate more variability in faculty pedagogical beliefs. Two of these beliefs in particular merit further consideration, given their prominence in faculty thinking and their potential influence on teaching practice.

Practice and perseverance. The most commonly reported belief in the study was that students best learn when engaged in a diligent course of study with the material on their own time (27 respondents). This perspective that hard work is a key feature of student learning and success at the undergraduate level in general, and in math and science disciplines in particular, is not without precedent. Some have pointed to practice and persistence as a critical predictor of student persistence in math and science disciplines (Drew, 2011). This is due in part to the perception that these fields are by nature difficult to master, such that without hours of study and practice it is difficult for students to learn and continue on to the next level of training. Interestingly, evidence suggests that undergraduate student study habits are changing in ways that may conflict with this foundational belief. Babcock and Marks (2011) found that the average full-time student at four-year colleges studied 14 hours per week in 2003, as compared to 24 hours per week in 1961. This decline holds true across most disciplines, even among engineering students who reported the most hours studied per week. Thus, the expectations faculty have regarding a basic and fundamental aspect of student learning and success—that of practice and persistence—may not be met by the study habits of contemporary students as measured in hours spent studying per week. The implications for this misalignment between faculty beliefs and expectations on the one hand, and on the actual studying habits and practices of students on the other hand, is an important question that should be pursued in future research. This is particularly important given that policymakers and researchers tend to focus on faculty teaching as one of the primary reasons contributing to student attrition and poor learning outcomes (e.g., PCAST, 2012; Seymour & Hewitt, 1997). The widespread nature of the belief regarding persistence and practice suggests that for many faculty in this study, poor student outcomes are due in part to students' amount of effort, and not just their own actions in the classroom. While I do not suggest the veracity of either perspective, there exists a tension between these different causes of poor outcomes (i.e., the student or the teacher) that should at least be acknowledged by policymakers and practitioners engaged in instructional improvement at the postsecondary level.

The practice and persistence belief also suggests that some faculty do recognize the merits of a deep and substantive engagement with the material as an important precursor to learning. This view is consistent with research from the learning sciences that demonstrates that long-term retention and comprehension is facilitated by encountering and persisting through challenging problems and tasks (e.g., Craik & Tulving, 1975; Diemand-Yauman, Oppenheimer, & Vaughan, 2011). While I do not suggest that the practice and persistence belief is informed by a nuanced appreciation of the learning sciences, it is possible that some faculty may have a folk theory of student learning that is supported in part by empirical evidence.

Variability and learning styles. Another widely held belief is that how students learn varies from person to person (20 respondents). The belief that students learn according to different styles, and that differentiated instruction should be provided to students of different abilities and background, is widespread in the educational literature. In the context of STEM education, Felder and Silverman (1988) argued that teachers should meet the needs of all learning styles (e.g., auditory, sensory, etc.), and that when mismatches occur between these styles and faculty teaching, results include student boredom and poor performance. However, the idea that learners have different learning preferences independent of ability and content, and that these have implications for learning outcomes, is without basis in the empirical literature (Riener & Willingham, 2010). While research does support the notion that students do have preferences for learning, adapting teaching styles to learning preferences makes no statistical difference under controlled conditions. As a result, Riener and Willingham (2010) argue that instructors should present information in an appropriate manner for the content and the level of prior knowledge of students, but not in terms of the different learning preferences of their students. It is important to note that the lack of experimental evidence does not prove that adapting teaching styles to student preferences has no impact on student learning in actual classrooms.

In any event, the salience of this cautionary note in relation to the data reported in this study is that faculty attempts to teach in accordance with various student learning styles are leading some instructors to diversify their pedagogical repertoire. For example, one instructor stated that given the range of student learning styles, he deliberately planned his classes to include lectures, hands-on exercises, readings, and web-based modules. Of course, the use of a diversified instructional approach may also be due to the growing use of instructional technologies and digital media by faculty, and not solely based on a belief about learning styles. One question raised by this finding is whether a differentiated approach to instruction, at least in terms of the use of particular teaching techniques, does in fact facilitate students in “making it their own” or if it results in an overly multimodal and incoherent approach to instruction. Future research on the specific relationship between faculty beliefs about student learning and their selection of particular teaching tools would shed light on this matter.

Underlying Dimensionality of Agent Constructing Knowledge/Meaning

The findings confirm prior research indicating that faculty thinking in general, and beliefs about student learning in particular, can be characterized according to a student-centered or a teacher-centered perspective (Kember, 1997; Samuelowicz & Bain, 2001). However, the evidence presented in this paper suggests that while faculty approaches to teaching could be characterized as being either student- or teacher-focused, they cannot always be considered mutually exclusive categories to which individuals can be assigned. This is because 66% of the respondents in the study (37) reported beliefs that were not limited to a single cluster or stand-alone belief. This result suggests instead that some faculty may hold more complex belief "systems" or combinations of beliefs (Nespor, 1987). Further, the case studies suggest that these beliefs are also linked to other cognitive constructs such as prior experience, goals, and perceived affordances, such that describing an individual's pedagogical thoughts in terms of a single type of belief may be an overly reductionist stance that obscures the complexity and systemic nature of faculty thinking (Postareff & Lindblom-Ylanne, 2008). In addition, based on the data, no conclusions regarding the hierarchical structure of belief types whereby one belief subsumes all others (e.g., Trigwell, Prosser, & Taylor, 1996), or the inherent sophistication of particular beliefs can be made (Entwistle & Walker, 2000; Linblom-Ylanne, Trigwell, Nevgi, & Ashwin, 2006). This latter point is particularly important because such conclusions may have important implications for practitioners and policymakers interested in improving postsecondary education. Instead of suggesting the superiority of student-centered beliefs (i.e., Cluster B), I interpret these findings as mere descriptions of the beliefs faculty have about student learning. That is, until and unless certain types of beliefs could be empirically linked to the enhancement of student learning outcomes, such evaluative judgments are premature. Furthermore, given that individual faculty frequently report multiple types of beliefs, characterizing a person with such complex beliefs as being sophisticated or not is without basis.

The Complex Relationship between Beliefs and Teaching Behaviors

As previously noted, prior research suggests that pedagogical beliefs have a linear and direct effect on faculty teaching practices. For example, Kember (1997) stated that "a lecturer who holds an information transmission conception is likely to rely almost exclusively on a unidirectional lecture approach" (p.270), and Pratt (1992) wrote that teacher self-reports of their beliefs and approaches to teaching should be viewed as "surrogate evidence for their actions" (p.206). I suggest that the data reported in this paper—that beliefs interact with prior experiences, goals, and perceived affordances to influence planning decisions—raises questions about such conclusions. Instead, the evidence indicates that there is not a simple one-to-one correspondence between beliefs and practice. Overall, the findings support recent evidence that suggests that the relationship between faculty cognition and classroom practice is more complex than previously thought. In one promising study, McAlpine and colleagues (2006) explicitly draw on a cognitive framework to explore how faculty create problem spaces for instruction that represents an internal mental model of the instructional situation. This perspective is consistent with the role that beliefs play in framing new situations or tasks, such that beliefs may be one of the more salient constructs at play in determining these problem spaces. Thus, beliefs are but one consideration or factor that enters into the course planning process.

Implications for Instructional Improvement at the Postsecondary Level

This study has implications for how policymakers, faculty developers, and education researchers approach instructional improvement at the postsecondary level. I suggest that the benefits of faculty development initiatives focused exclusively on supporting faculty to adopt student-centered beliefs are unsupported by empirical research. This is not to say that professional development should not place teachers and their growth at the center of instructional reform efforts, nor that teacher thinking is inconsequential in regards to classroom practice. As Fullan stated, "educational change depends on what teachers do and think – it's as simple and as complex as that" (2001, p.115). However, I suggest that given the lack of evidence regarding the links among faculty beliefs, teaching, and student outcomes, faculty developers would be better served in taking a broader outlook on faculty practice that encompasses the organizational context, pedagogical skills and techniques, and aspects of cognition. Such a systems-oriented approach is common in the K-12 sector (e.g., Clarke & Hollingsworth, 2002; Putnam & Borko, 1997) in large part because of the recognition that teaching practice is situated within specific instructional settings. Promising examples of such an approach exist at the postsecondary level and programs that aim to deepen the pedagogical skill set and knowledge base of faculty while also addressing the constraints and affordances posed by the local context should be encouraged in the future (Saroyan & Amundsen, 2001).

Another argument against the singular promotion of student-centered beliefs is the potential of such approaches to have the unanticipated effect of alienating faculty and fostering resistance to pedagogical improvement. Some observers of instructional reform efforts in higher education state that the dominant approach to organizational change promoted by funding agencies such as the NSF are based on a top-down theory of behavior change (Fairweather, 2008). That is, projects demonstrated to be successful at one location can be exported to other locations with the expectation of wholesale adoption. By coming into local colleges and universities with a priori assumptions about matters such as effective curriculum, the sources of poor educational outcomes (e.g., the faculty) and the role of faculty beliefs, educational designers may be fostering resentment among faculty who feel as if their experiences and perspectives are being ignored (Henderson & Dancy, 2008). As Henderson and Dancy (2008) point out:

> Instead of making them feel they are bad teachers and that they are being told to adopt research innovations (for instruction) because the researchers know best, these instructors would like the (educational) research community to recognize that they have valuable experiences and expertise and work with them to improve teaching and learning (p. 86).

Given that an important aspect of faculty experiences and belief systems appears to be the sentiment that student learning is largely dependent upon hard work and practice, I recommend that policy statements and professional development initiatives that focus exclusively on faculty behaviors as the primary cause of student outcomes at the very least acknowledge the role of student study habits and persistence in determining their success or failure. This suggestion is based in part to evidence that what some perceive as resistance is not just a belligerent reaction against change but may be a principled response to innovations or policies that are viewed as contrary to local practices and beliefs as well as detrimental to organizational functioning (Piderit, 2000). Similarly, research on reform implementation in the K–12 sector demonstrates that policies and innovations will be interpreted, adopted or rejected, and adapted largely based on the cognitive frameworks of teachers as they function within specific contexts (Spillane, Reiser, & Reimer, 2002). Thus, designing professional development initiatives that pay close attention to local practices, traditions, and conditions may increase the chances that a new policy or innovation will be accepted (Cobb, Zhao, & Dean, 2009). One of the ways that detailed insights into local practice can be translated into practice is to identify locally salient ways of thinking and acting that could be built upon when designing an intervention.

Conclusions

Based on the findings and analysis presented in this paper, fruitful avenues for future research that address the relationship among cognition, context, and practice are apparent. I identify four approaches here.

- Instead of seeking to establish causal links among belief types, faculty teaching, and student outcomes, efforts should be made to produce more detailed and rigorous descriptions of practice in the field.

- Future research in this area should consider focusing on domain-specific beliefs and their relationship to specific instructional practices. That is, instead of eliciting generalized beliefs about teaching and learning and linking them to correspondingly generalized teaching behaviors, researchers should aim at more finely grained beliefs and practices.

- Given prior research that indicates beliefs can act to filter new information, frame problems and tasks, and guide activity, future research should explore precisely how beliefs may act to influence faculty teaching in these ways.

- Research focusing on how beliefs may influence practice through unconscious or automatic mechanisms should be conducted, largely due to increasing evidence that much of human action is determined by processes outside of conscious awareness (Bargh, 2005; Feldon, 2007). In any case, a more multidimensional and nuanced approach to the study of faculty teaching is warranted, and promises to shed light on critical issues related to educational improvement at the postsecondary level.

References

Abelson, R. P. (1979). Differences between belief and knowledge systems. *Cognitive Science, 3*(4), 355–366.

Armitage, C. J., & Conner, M. (2000). Social cognition models and health behavior: A structured review. *Psychology and Health, 15*(2), 173-189.

Babcock, P. S., & Marks, M. (2011). The Falling Time Cost of College" Evidence from a Half Century of Time Use Data. *Review of Economics and Statistics 93*, 468–78.

Bailey, J. G. (1999). Academics' motivation and self-efficacy for teaching and research. *Higher Education Research & Development, 18*(3), 343.

Ball, D. L. (1988). Unlearning to teach mathematics. *For the Learning of Mathematics, 8,* 40–48.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84* (2), 191–215.

Bargh, J. A. (2005). Bypassing the will: Toward demystifying the nonconscious control of social behavior. In R. R. Hassin, J. S. Uleman, & J. A. Bargh (Eds.), *The new unconscious: Oxford series in social cognition and social neuroscience* (pp. 37–58). Oxford, England: Oxford University Press.

Blumenfeld, P. C., Kempler, T. M., & Krajcik, J. S. (2006). Motivation and cognitive engagement in learning environments. In R. K. Sawyer, (Ed.), *The Cambridge handbook of the Learning Sciences* (pp. 475–488). New York, NY: Cambridge University Press.

Borko, H., Eisenhart, M., Brown, C. A., Underhill, R. G., Jones, D., & Agard, P. C. (1992). Learning to teach hard mathematics: Do novice teachers and their instructors give up too easily? *Journal for Research in Mathematics Education, 23,* 194–222.

Borko, H., & Shavelson, R. J. (1978). Teachers' sensitivity to the reliability of information in making thematic attributions in an achievement situation. *Journal of Educational Psychology, 70* (3), 271–279.

Burns, R. A. (1985). Information impact and factors affecting recall. Paper presented at Annual National Conference on Teaching Excellence and Conference of Administrators, Austin, TX, May 22-25 (ERIC Document No. ED 258 639).

Carayon, P. (2009). The balance theory and the work system model…. Twenty years later. *International Journal of Human-Computer Interaction, 25* (5), 313–327.

Chi, M. T. H. (1997). Quantifying qualitative analyses of verbal data: A practical guide. *The Journal of the Learning Sciences, 6* (3), 271–315.

Clark, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, *18*, 947–967.

Cobb, P., Zhao, Q., & Dean, C. (2009). Conducting design experiments to support teachers' learning: A reflection from the field. *Journal of the Learning Sciences, 18*(2), 165–199.

Cohen, D. K., & Ball, D. L. (1999). *Instruction, capacity, and improvement*. Consortium for Policy Research in Education Research Report Series RR-42, University of Philadelphia, PA.

Craik, F., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology*, *104*(3), 268–294.

Diemand-Yauman, C., Oppenheimer, D. M., & Vaughan, E. B. (2011). Fortune favors the bold and the italicized: Effects of disfluency on educational outcomes. *Cognition, 118* (1), 111–115.

Drew, C. (2011, November 4). Why science majors change their minds (It's just so darn hard). *New York Times*.

Eley, M. G. (2006). Teachers' conceptions of teaching, and the making of specific decisions in planning to teach. *Higher Education, 51*, 191–214.

Entwistle, N., & Walker, P. (2000). Strategic alertness and expanded awareness within sophisticated conceptions of teaching. *Instructional Science*, *28,* 335–361.

Entwistle, N., Skinner, D., Entwistle, D., & Orr, S. (2000). Conceptions and beliefs about "Good teaching": An integration of contrasting research areas. *Higher Education Research & Development*, *19*(1), 5–26.

Felder, R. M., & Silverman, L. (1988). Learning and teaching styles in engineering education. *Engineering Education*, *78*(7), 674–681.

Feldon, D. F. (2007). Cognitive load and classroom teaching: The double-edged sword of automaticity. *Educational Psychologist, 42*(3), 123–137.

Fives, H., & Buehl, M. M. (2012). Spring cleaning for the "messy" construct of teachers' beliefs: What are they? Which have been examined? What can they tell us? In K. R. Harris, S. Graham, T. Urdan, S. Graham, J. M. Royer, & M. Zeidner (Eds.), *APA educational psychology handbook, Vol. 2: Individual differences and cultural and contextual factors* (pp. 471–499). Washington, DC: American Psychological Association.

Fullan, M. (2001). *The new meaning of educational change* (3rd ed.). Toronto, Canada: O.I.S.E. Press.

Geertz, C. (1973). *The interpretation of cultures*. New York, NY: Basic Books.

Gibbs, G., & Coffey, M. (2004). The impact of training of university teachers on their teaching skills, their approach to teaching, and the approach to learning of their students. *Active Learning in Higher Education*, *5*(1), 87–100.

Glaser, B. G., & Strauss., A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New Brunswick, NJ: Aldine Transaction.

Greeno, J. G. (1998). The situativity of knowing, learning, and research. *American Psychologist*, *53*(1), 5–26.

Halpern, D. F., & Hakel, M. D. (2003). Applying the science of learning to the university. *Change*, 36–41.

Hativa, N., Barak, R., & Simhi, E. (2001). Exemplary university teachers: Knowledge and beliefs regarding effective teaching dimensions and strategies. *The Journal of Higher Education, 72*(6), 699–729.

Hativa, N., & Goodyear, P. (Eds.) (2001). *Teacher thinking, beliefs, and knowledge in higher education.* Norwell, MA: Kluwer Academic Publishers.

Henderson, C., & Dancy, M. H. (2008). Physics faculty and educational researchers: Divergent expectations as barriers to the diffusion of innovations. *American Journal of Physics*, *76*(1), 79–91.

Henderson, C., & Dancy, M. H. (2007). Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics. *Physical Review Special Topics—Physics Education Research, 3*(2), 1–14.

Ho, A., Watkins, D., & Kelly, M. (2001). The conceptual change approach to improving teaching and learning: An evaluation of a Hong Kong staff development programme. *Higher Education, 42*(2), 143–169.

Hora, M. T., & Ferrare, J. (in press). Instructional systems of practice: A multi-dimensional analysis of math and science undergraduate course planning and classroom teaching. *Journal of the Learning Sciences.*

Kane, R., Sandretto, S., & Heath, C. (2002). Telling half the story: A critical review of research on the teaching beliefs and practices of university academics. *Review of Educational Research, 7*2(2), 177–228.

Kember, D. (1997). A reconceptualisation of the research into university academics’ conceptions of teaching. *Learning and Instruction*, *7*, 255–275.

Lattuca, L. R. (2005). Faculty work as learning: Insights from theories of cognition. *New Directions for Teaching and Learning* (102) 13–21.

Lee, O., & Porter, A. (1990). Bounded rationality in classroom teaching. *Educational Psychologist*, *25*(2), 159–171.

McAlpine, L., Weston, C., Timmermans, J., Berthiaume, D., & Fairbank-Roch, G. (2006). Zones: Reconceptualizing teacher thinking in relation to action. *Studies in Higher Education, 31*(5), 601–615.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage Publications.

National Research Council (2010). *Rising above the gathering storm, revisited: Rapidly approaching category 5.* Washington DC: The National Academies Press.

Nathan, M. J., & Koedinger, K. R. (2000). An investigation of teachers' beliefs of students' algebra development. *Cognition and Instruction, 18*(2), 209–237.

Neal, E., & Peed-Neal, I. (2009). Experiential lessons in the practice of faculty development. In L. B. Nilson, & J. E. Miller (Eds.), *To improve the academy*, (pp. 14–31). The Professional and Organizational Development Network in Higher Education.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19,* 317–328.

Norton, L., Richardson, J. T. E., Hartley, J., Newstead, S., & Mayes, J. (2005). Teachers' beliefs and intentions concerning teaching in higher education. *Higher Education, 50*(4), 537–571.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, *62*, 307–332.

Pedrosa-de-Jesus, H., da Silva Lopes, B., Moreira, A., & Watts, M. (2012). Contexts for questioning: two zones of teaching and learning in undergraduate science. *Higher Education*. doi: 10.1007/s10734-012-9512-9

Piderit, S. K. (2000). Rethinking resistance and recognizing ambivalence: A multidimensional view of attitudes toward an organizational change. *Academy of Management Review, 21*(4), 783–794.

Postareff, L., & Lindblom-Ylanne, S. (2008). Variation in teachers' description of teaching: Broadening the understanding of teaching in higher education. *Learning and Instruction*, *18*, 109–120.

Postareff, L., Lindblom-Ylanne, S., & Nevgi, A. (2007). The effect of pedagogical training on teaching in higher education. *Teaching and Teacher Education, 23*, 557–571.

Pratt, D. D. (1992). Conceptions of teaching. *Adult Education Quarterly, 42*(4), 203–220.

President's Council of Advisors on Science and Technology (2012). *Report to the President. Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering and mathematics*. Washington, DC: Executive Office of the President.

Prosser, M., Trigwell, K., & Taylor, P. (1996). A phenomenographic study of academics' conceptions of science learning and teaching. *Learning and Instruction, 4*, 217–231.

Putnam, R. T., & Borko, H. (1997). Teacher learning: Implications of new views of cognition. In B. J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *International handbook of teachers & teaching* (Vol. II, pp. 1223–1296). Dordrecht, Netherlands: Kluwer.

Roche, L. A., & Marsh, H. W. (2000). Multiple dimensions of university teacher self-concept. *Instructional Science, 28*, 439–468.

Samuelowicz, K., & Bain, J. D. (1992). Conceptions of teaching held by academic teachers. *Higher Education, 24*, 93–111.

Samuelowicz, K., & Bain, J. D. (2001). Revisiting academics' beliefs about teaching and learning. *Higher Education, 41*, 299–325.

Saroyan, A., & Amundsen, C. (2001). Evaluating university teaching: time to take stock. *Assessment & Evaluation in Higher Education, 26*(4), 341–353.

Schoenfeld, A. H. (2000). Models of the teaching process. *Journal of Mathematical Behavior, 18*(3), 243–261.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Shavelson, R. J., & Stern, P. (1981). Research on teachers' pedagogical thoughts, judgments, decisions, and behavior. *Review of Educational Research, 51*(4), 455–498.

Shavelson, R. J., & Borko, H. (1979). Research on teachers' decisions in planning instruction. *Educational Horizons, 57*, 183–189.

Spillane, J. P., Reiser, B. J., & Reimer, T. (2002). Policy implementation and cognition: Reframing and refocusing implementation research. *Review of Educational Research, 72*(3), 387–431.

Spillane, J. P., Halverson, R., & Diamond, J. B. (2001). Investigating School Leadership Practice: A Distributed Perspective. *Educational Researcher, 30*(3), 23–28.

Spradley, J. P. (1979). *The ethnographic interview*. New York, NY: Harcourt, Brace, Janovich.

Tashakkori, A., & Teddlie, C. B. (Eds.). (2002). *Handbook of mixed methods social and behavioral research.* Thousand Oaks, CA: Sage Publications.

Trevino, L. K. (1986). Ethical decision making in organizations: A person-situation interactionist model. *The Academy of Management Review*, *11*(3), 601–617.

Trigwell, K., & Prosser, M. (2004). Development and use of the Approaches to Teaching Inventory. *Educational Psychology Review, 16*, 409–424.

Trigwell, K., Prosser, M., & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning. *Higher Education*, *37*, 57–70.

Trigwell, K., Prosser, M., & Taylor, P. (1996). Qualitative differences in approaches to teaching first year university science. *Higher Education*, *27*(1), 75–84.

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*, 202–248.

Yin, R. (2008*). Case study research: Design and methods*. (4th ed). Thousand Oaks, CA: Sage Publications.