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"Uncentering" Teacher Beliefs: The Expressed Epistemologies of Secondary Science Teachers and How They Relate to Teacher Practice

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This multi-university, three-year longitudinal study examined the relationship among seven secondary science teachers' personal, student and scientific epistemologies. Paying close attention to each participant's use of metaphor when speaking about his/her learning, students' learning and the products/processes of science, we were able to discern each participant's epistemological stance as indicating the acquisition metaphor of learning or the participation metaphor of learning or some combination of the two (pluralistic). We compared video recordings of each participant's classroom teaching practice to develop an understanding for how their epistemological stance might relate to that practice. Based on our results, we contradict the current paradigm that beliefs guide practice, by positing that practice might actually determine beliefs. Where teachers having more field experiences were more likely to talk about learning through doing (participation) and those whose practice emphasized knowledge transfer, adhered to the acquisition metaphor for student learning. If teacher practice influenced their beliefs, this has profound implications for the structure of teacher education programs.

Keywords: Science teaching, epistemology, teacher beliefs, teacher practice, metaphors of learning.

INTRODUCTION

In spite of the contentious debate regarding teacher education practices in the United States, education reformers and policymakers are unified in their belief that teacher quality matters. Only recently have researchers been able to identify the true magnitude of high quality teaching on student outcomes over the course of their lifetime. Using large data sets linking student achievement data and income tax records, Chetty et al., (2013) determined that on average, having a top 5% highly-qualified teacher for one year raises a child's cumulative lifetime income by $50,000. For a class of average size (28 students), the cumulative lifetime income gains of having an exemplary teacher for a *single year* surpass $1.4 million. Numerous other studies have demonstrated that teacher effectiveness is the single largest determinant of student achievement regardless of the multitude of contextual variables present in today's classrooms (Boyd, Lankford, Loeb, Rockoff, & Wyckoff, 2008; Clotfelder, Ladd, & Vigdor, 2007; National Research Council (NRC), 2002; Rivkin, Hunshek, & Cain, 2005).

While the value of high quality teachers is undisputed, the most effective ways to recruit, prepare, and retain teachers for complex and dynamic 21st-century classrooms is far less obvious. A review of the research literature demonstrates the highly contested arguments about how best to prepare effective science teachers (Boyd, et al., 2008; Darling-Hammond & Bransford, 2005; Grossman, 2008; NRC, 2010). Some policymakers have even questioned the value of teacher education programs altogether and have proposed a variety of alternative pathways for placing teachers in our nation's schools. A recent report from the National Research Council (2010) concluded that teacher preparation programs are often viewed as an "afterthought" in the discourse pertaining to the reform of our public education system. Many education policy experts believe that the controversy surrounding teacher preparation is driven by the lack of empirical evidence regarding the efficacy of existing teacher education programs

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and practices (Cochran-Smith & Zeichner, 2005; Grossman, 2008; NRC, 2010; Wilson, Floden, & Ferrini-Mundy, 2001; Windshitl, 2005). If the true effectiveness of preservice teacher education programs in the preparation of highly qualified science teachers is to ever be accurately assessed, researchers must establish empirical evidence that demonstrates the links between teacher preparation, classroom instruction, and K – 12 student learning. A better understanding of these connections can act as a lens to guide practice and provide valuable feedback necessary to improve the overall quality of science teacher education programs (Schalock, 2004; Tobias, 2010).

Education scholars have cited the specific need for more longitudinal, comprehensive studies of science teacher preparation programs across multiple universities that investigate how learning experiences within preservice programs impact science teachers' beliefs and instructional practices (Luft, 2007; Mansour, 2009; Tillotson & Young, 2013). Previous studies indicate that even teachers who graduate from reform-oriented teacher education programs often struggle to implement reform-based instructional practices once they enter the classroom for a variety of personal and contextual reasons (Davis, Petish, & Smithey, 2006; Leuhmann, 2007; McGinnis, Parker, & Graber, 2004; Simmons, at al., 1999; Tillotson & Young, 2013). The emphasis on active learning promoted within many teacher preparation programs often requires teachers to take on new, unfamiliar roles in the classroom. Few preservice teachers have experienced this type of student-centered, inquiry-oriented learning environment directly as students themselves, and thus they often struggle when translating these expectations into their new role as a teacher (Korthagen, 2004). Tsai (2002) suggests that many science teachers may continue to hold traditional views about science teaching and learning, as well as the nature of science, because their beliefs are reinforced as a result of their science courses and laboratory experiences during their teacher preparation programs that are inconsistent with the reform-oriented ideals promoted in preservice science education courses.

Many scholars contend that teachers' attitudes and beliefs about reform-based science instruction are strongly influential in the enactment of their instructional practices (Haney, Czerniak, & Lumpe, 1996; Pajares, 1992; Richardson, 1996; Roehrig & Kruse, 2005; Savasci & Berlin, 2012). However, more recent studies have begun to question the directionality of the link between epistemological beliefs and instructional practices (Jones & Carter, 2007; Mansour, 2009). In his detailed review of the literature on teacher beliefs and practices, Mansour (2009) argues that the identified relationship between teachers' beliefs and instructional practices is far from being straightforward. He notes that, "Beliefs can be contradictory, and compete for priority; b) have indirect, but strong effects on teaching practice; and c) are often context-dependent, so that they have differing strengths in differing contexts" (p. 32).

Given the complex role that teacher's beliefs play in teacher decision-making, it's clear that research on the efficacy of teacher education programs must explore in greater depth the interplay between the development of science teachers personal epistemologies and the link to their instructional practices. To influence policymakers, teacher educators should engage in studies that, "look across different preparation programs and support more robust assertions about particular approaches by including larger numbers of participants and/or that seek to compare across different programs. This means having teams of researchers at different sites who can identify similar outcome measures use common instruments for data collection. These types of studies are complex, long-term, and expensive. Perhaps this is why they are almost nonexistent." (Windschitl, 2005, p. 529).

The purpose of this particular study was to identify the epistemological stances (personal, student, and scientific) of preservice secondary science teachers at three major research universities located in the United States. Our goal was to determine the relationship among these epistemological stances, if one exists, to determine how these epistemological stances might be related to the teacher participants' classroom practices, and to trace teacher beliefs and practices to specific teacher education program (TEP) interventions which may have been influential in shaping their beliefs and practices.

LITERATURE REVIEW

History of research on beliefs. In their review of the literature of teachers' attitudes and beliefs, Jones and Carter (2007) found that starting from the 1940s, born out of behaviorist research, investigations were focused mainly on teachers' attitudes towards science and teaching science. The premise of research was, "attitudes could be used to predict teaching behavior and that a change in attitude would result in changes in behavior" (p. 1070). In the 1970s, studies began to focus more on interventions that affect beliefs using mainly quantitative methods such as surveys. More recently, the idea of studying individual experiences in a qualitative manner has become much greater. With titles like, *Dispositions in Supporting Elementary Interns in Practice…*, *Teachers' Understanding of the Nature of Science and Classroom Practice…*, *Capturing Science Teachers' Epistemological Beliefs…*, it is obvious that the center of study remains, as it was, discerning teachers' beliefs to make sense of, predict, and eventually influence their practice.

What are beliefs and how are they determined? The term *belief* as defined by the *Oxford English Dictionary* (OED, 1994) is the "mental acceptance of a proposition, statement, or fact as true on the ground of authority or evidence; assent of the mind to a statement, or to the truth of a fact beyond observation, on the testimony of another, or to a fact or truth on the evidence of consciousness" (p. 123). Despite this definitive description, the definition of *belief* used in the research literature has a much broader range of uses. Teachers' beliefs were seen as a referent part of existing knowledge that guides actions (BouJaoude, 2000), a psychological construction that have conceptions or propositions that are felt to be true and may guide action, be linked to emotions and do not have the prerequisite of having to be true (Bryan, 2003). For an extensive list of the varied definitions found in the literature, we direct the reader to Jones and Carter (2007, p. 1069).

The types of beliefs important to this paper are epistemological. These beliefs are specific to how a person thinks about the nature of knowledge and their relationship to it. Epistemological beliefs answer the question, "How do we know what we know?" Current research has been interested in exploring teachers' (preservice and in-service) personal epistemologies, student epistemologies (how students know and learn) and scientific epistemology (the nature and origin of scientific knowledge) (Ching 2009; Kienhues, Braomme, & Stahl, 2008; Luft& Roehrig, 2007; Tsai, 2007; Waters-Adams, 2006).

Researchers have developed instruments for ascertaining beliefs about science utilizing closed-ended (Aikenhead & Ryan, 1992), and the open ended questions (Chai, Teo, & Lee, 2009; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Others have developed interview protocols (Richardson & Simmons, 1994; Luft & Roehrig, 2007). Teacher interviews were a major part of some research (Hodson, 1993; Southerland, Johnston, & Sowell, 2006; Tsai, 2002). Other strategies included drawings (Minogue, 2010), written metaphors (BouJaude, 2000; Reeder, Utley, & Cassel, 2009), and critical incidents (Kang & Wallace, 2005).

Epistemological alignment and relationship to classroom practice. In some cases of inquiry into teachers' epistemologies, researchers have found coherence among personal, student and scientific epistemologies, a circumstance referred to as "nested epistemologies" (Bryan, 2003; Tsai, 2002, 2007). However, other researchers have also found instances where participant epistemologies were not aligned (Kinchin et al., 2009; Waters-Adams, 2006)

In studies investigating the relationship between epistemology and practice, there are a few reports where a teacher's classroom practice seemed to reflect his/her expressed epistemology (Brickhouse, 1990; Tsai, 2007). In contrast, the connection between epistemology and practice has also been a challenge for others. Lederman (1999) and Hodson (1993), for instance, found that what teachers often espoused as their beliefs about science, teaching and learning did not align with the practice the investigators observed while those participants taught. Kang and Wallace (2005) found, in general, that the link from epistemology to actions was fairly straightforward when the epistemology was naïve but was less well constrained as the epistemological stance became more sophisticated. Teachers separated "ideal science" from what they can do in the classroom based on the teaching context and their goals. Teacher goals related closely to their ontological beliefs. Finally, they asserted that the relational aspect of their epistemology (knowledge as external, or knowledge as personal) seemed to guide the design of instructional activities.

It was with the above findings in mind that we conduct the current study. We seek to identify each participant's personal, student, and scientific epistemologies. In other words, we analyze our data to determine how each participant considered the development of their personal knowledge, how they considered the students developing their personal knowledge, and how they considered the development of scientific knowledge, respectively. Upon identifying these epistemologies, we discern relationships among them and then relationships with their classroom practice. Finally, we seek to discern whether there are connections among epistemologies, practice and TEPs.

METHODS

Because this current investigation is a small part of a much larger project, we thought it would be worth contextualizing it by giving a brief description of the larger National Science Foundation funded IMPPACT project.

The IMPPACT Project. Building on the earlier Salish Research Projects (Salish I Research Project, 1997; Robinson, & Yager, 1998; Simmons, et al, 1999), the IMPPACT Project (Investigating the Meaningfulness of Preservice Programs Across the Continuum of Teaching in Science Education) was funded through a $2.48 million grant from the US National Science Foundation to collect extensive teacher, pupil, and teacher education program data over a three-year period. IMPPACT research teams gathered data from approximately 150 teacher graduates of these three secondary science teacher education programs who were teaching in 7-12 grade science classrooms all across the United States. The purpose of our research investigation was: 1) to better understand secondary science teachers' learning of content and pedagogy over time as a result of key interventions within these three preservice science teacher preparation programs; 2) to assess the subsequent impact of this learning on their classroom teaching; and 3) to determine what factors significantly influenced these secondary science teachers' beliefs and classroom practices following graduation from our preservice programs. Specifically, our study targeted the longitudinal impact of preservice science teacher education program learning experiences on secondary science teachers and their students (grades 7-12) across four critical stages of a teacher's career continuum.

The IMPPACT researchers examined how learning experiences in science teacher education—in both pedagogy courses and science content courses— influenced science teachers' knowledge, beliefs and classroom practices, as well as the student learning outcomes for pupils in their 7-12 grade science courses. An emphasis was placed on exploring the developmental process that occurs during the preservice, induction, and post-induction years related to teachers' beliefs and practices. We further examined how the enculturation process for beginning science teachers within US secondary schools influences their beliefs and actions longitudinally as they transitioned from their preservice program to full-time teaching.

The IMPPACT Project served as a comprehensive model for exploring how both content and pedagogy experiences in teacher education ultimately shape the practices of secondary science teachers at various stages of their professional career (Tillotson & Young, 2013). As part of our IMPPACT model, interdisciplinary research teams consisting of science teacher educators, scientists and doctoral research associates at each participating university were responsible for collecting and analyzing data from key stakeholders.

The three preservice programs selected for inclusion in the IMPPACT study universities were purposely chosen as research sites because the project investigators chose to focus on large, doctoral-granting institutions that were similar in size, characteristics, and preservice program features, yet located in different geographic regions of the US. This allowed our research team to investigate how these program interventions impact science teacher development in the broadest range of secondary school settings possible (Tillotson & Young, 2013). The preservice program features studied included both undergraduate and graduate certification degree programs, varying amounts of science content coursework, varying numbers of science methods courses, variable field placements at multiple grade levels in socio-economically and culturally diverse schools, specialized courses in technology, assessment, and/or science-technology-society applications, and differing levels of emphasis on the nature of science within each program. The diverse array of program features across these three institutions allowed for strategic within- and cross-site comparisons to be made related to each of our primary research questions.

Questions. Three questions form the basis of the current study.

- *Do teachers' scientific epistemologies align with their personal and student epistemologies?*
- *What is the relationship between teachers' epistemologies and their observed classroom practice?*
- *What role might the participants' TEP play in shaping their beliefs and/or classroom practice?*

The teacher education programs. Each of the TEPs is a combined undergraduate/graduate degree-granting program. They were chosen because they each had certain program interventions in common and they had some specific differences as well. The goal is not to judge whole programs but to look at the different interventions and how they might relate to teachers' beliefs and practice. Some of the differences that we were particularly interested in were the placement and duration of student teaching, the placement and duration of nature of science instruction, and the integration of methods classes with student teaching. A summary of the different interventions can be found in Table 1.

Data collection and participants. We utilized two different instruments in our data collecting procedures, the *Beliefs and Nature of Science Interview Protocol (BNOS)* and the *Reflections on Preservice Program Experiences Interview Protocol (RoPPE)*. The BNOS (after Richardson & Simmons, 1994) is a 17-question semiannual interview asking participants' to describe their beliefs about effective science instruction, their philosophy on learning and how students learn, and their views on the nature of science. Two readers rated the interview using an interview map (Luft, et al., 2003). The *RoPPE* (Tillotson, Yager, & Penick, 2007) is a 22 question exit interview asking participants to describe how experiences within their TEP influenced their beliefs and practices. We administered it during spring, 2009.

Table 1.
Summary of Interventions and Their Implementation by University

Program	Multiple	Cohort	Diverse placements	Reflective practices				NOS	Educational technology	Applications of science	STS
				Rationale paper	Action research	Video reflection	Micro-teach				
SPU	2 classes	Incidental	**342.5** hours			2 times		Taught within methods	1 class		
NPU	2 classes	Purposeful	**540** hours middle and secondary, urban and suburban	1 semester		2 times		1 class			
MPU	3 classes	Purposeful	**720** hours elementary middle, and secondary	3 semesters		2 times		2 classes	1 class	At least 2 classes	

Table 1 This is a list of interventions for the three different university teacher education programs. Gray-tone indicates the implementation of a particular intervention by the university. The text within specific boxes gives some indication about its implementation.

The project investigators randomly sampled four cohorts of preservice and in-service science teachers at each university: entry into TEP (cohort 1); candidacy (cohort 2); early induction (years 1-4) (cohort 3); and the post-induction (years 5+) (cohort 4). Approximately 10 participants per site were chosen as in-depth participants from whom we collected semiannual qualitative interview data and videotaped observations.

For this study, we discerned a subset of in-depth participants by using the Nature of Science (NoS) portion of the *BNOS*. We calculated a mean score of the NoS portion of all of the coded interviews based on participant TEP. Once we ascertained these mean scores for all participants in each TEP (SPU mean=11.9, SD=3.1; NPU mean=13.6, SD 3.2; MPU mean=19.1, SD=4.0) we looked for participants who scored their particular TEP mean as a way to garner a representative sample of all in-depth participants within each TEP based on their understanding of the nature of science. For SPU this meant looking for participants with a score of 12, for NPU, a score of 14, and for MPU a score of 19. Because we were looking at possible TEP influence on beliefs and/or practice, we only picked participants with a mean NoS score who had already graduated from their program and were out in the field teaching. Once we chose the participants, we analyzed that particular *BNOS* in its entirety, we analyzed each participant's *RoPPE* and all videos of their teaching. Observed classes ranged from two to four classes running from 40 to 80 minutes in length each.

DESCRIPTION OF PARTICIPANTS

Alexander identified himself as a white male who taught high school science in a large urban school district in the Southeast, with an enrollment of over 2,500 students in grades 9-12. He had also attained his master's degree at the time of the IMPPACT study. When asked to describe his school and his students, Alexander indicated that approximately 32% of the students were eligible for free or reduced lunch and that over 75% of his students were of color. In comparison to his own high school experience, Alexander noted that the science students he taught were of a lower socioeconomic status than his own high school peers. The target class that he used for the study had a state-mandated, end-of-course standardized exam that all students were required to complete.

Mark identified himself as a white male who had completed an advanced degree in science above his master's degree. He taught secondary science in a 9-12 grade school building that was part of a large urban school in the Southeast, with approximately 2,300 pupils. Close to 40% of the students in Mark's school were eligible for free or reduced lunch and approximately 50% of the students were from underrepresented minority groups. The science course mark selected for the IMPPACT study had a required end-of-course assessment exam that was mandated by the state education department. When asked to compare the socioeconomic status of his current students to his own high school peers, Mark noted that his current students are more economically disadvantaged.

Erica described herself as a white female who had earned a master's degree in science education and was teaching secondary science at a large urban school in the Northeast. She estimated her school population at close to 1,600 students in grades 9-12, with 58% of the students receiving free or reduced lunch and 75% as being from underrepresented minority groups. The class she used as her target group for the IMPPACT study had a required State Exam at the conclusion that was mandated by the state education department. Erica also believed her current students were far more economically disadvantaged than her own high school peers.

Laura characterized herself as a white female who had earned her master's degree in science education and was now teaching in a small, rural school in the Northeast with only about 600 pupils in grades 6-12. Her primary teaching focus was at the middle school science level in grades 7-8. Only 30% of her school's students were eligible for free or reduced lunch, and like many rural schools in her state, Laura's students were predominantly white with less than 10% being students of color. The students in her target class were required to take a high-stakes, standardized science exam required by the state education department at the conclusion of the course. In her particular case, Laura felt as though the students she taught were very comparable to her own middle school peers with regard to their socioeconomic status.

Christine self-reported as a white female who taught high school science in a suburban school (1,500 students in grades 9-12) in the Northeast. She earned her master's degree in science education along with her science teacher certification for grades 7-12. Christine's school was what she considered to be a well-resourced school district with only about 7 % of the students qualifying for free or reduced lunch. Her school was also fairly homogeneous with less than 10% of the students from underrepresented minority groups. In her estimation, Christine's students were very comparable to her own high school peers in terms of their socioeconomic status. Her target course also featured a mandatory high-stakes exam at the end of the school year required by the state education department.

Courtney was a white female who taught middle school science in a suburban school in the Midwest that enrolled close to 1,000 students in grades 8-9. She held an advanced degree in science education beyond her master's degree. Only about 9% of the students in Courtney's school were eligible for free or reduced lunch and less than 10% of the students classified as underrepresented minorities. In comparing her students to her own middle school peers, she felt they were comparable in terms of socioeconomic status. The target class that Courtney used for the IMPPACT study did not have any type of required end-of-year high-stakes assessment mandated by the state.

Joyce described herself as white female who earned a master's degree and 7-12 grade science teacher certification. She was teaching 9-12 grade science in a midwestern community that had a population of approximately 25,000 people. Her schools enrolled about 1,600 students in grades 9-12 with 40% eligible for free or reduced lunch and less than 10% of the students were from underrepresented minority groups. Joyce felt that the socioeconomic status of her current students was actually lower than that of her own high school peers. Like Courtney, Joyce did not have any type of state-mandated exam that was required at the conclusion of her science course.

DATA ANALYSIS

Theoretical framework. We analyzed the interview data utilizing an *experientialist* (Lakoff & Johnson, 1980, 1999) theoretical framework. Experientialism rests on the understanding that we make meaning about our environment through the concrete experiences of our five senses (embodied experiences). Because we live in a similar environment and have a similar biology, the meanings we make from our experiences, though personal, are similar enough with each other (a family resemblance) that we can communicate about those experiences with each other in a meaningful way. Experientialism also explains that we develop knowledge about, or come to understand abstract concepts by projecting the meanings of our concrete experiences onto abstract concepts through the use of metaphor. Carey (2008), Clement (2010) and Nersessian (2009) also described similar mechanisms for the use of existing knowledge to build new knowledge.

We are analyzing interview data within the context the participants' use of metaphor to inform on his or her beliefs; how they structure their reality. Reeder et al (2009), and Tobin and LeMaster, (1995) asserted that the analysis of metaphors can give insight into how preservice teachers conceived the role of teachers and students. Kahnneman (2011) and Lakoff and Johnson (1980, 1999), highlighted the importance of how the metaphors we use in our everyday actions and communications can reveal the conceptual systems (or beliefs) we maintain. They went on to assert that metaphors, aside from being a poetic device of the imagination, are "pervasive in everyday life" (p.

3). Some metaphors are so fundamental to the concepts they associated with that they actually shape the way we perceive the concept itself, in other words, "the very systematicity that allows us to comprehend one aspect of the concept in terms of the other (e.g., comprehending the aspects of an argument in terms of a battle) will necessarily hide other aspects of the concept...that are inconsistent with that metaphor" (Lakoff & Johnson, 1980, p.10).

One place where we find the use of metaphor that is salient to the current research is in discussions and research about learning, and teaching. To the present, educational researchers have looked at learning from several major theoretical and epistemological schools of thought. Two schools that have garnered the most attention. The first explains learning as an individual acquiring or constructing knowledge within his/her head, or what (Bereiter, 2002) referred to as the *mind as container*. Sfard (1998) labeled this concept of learning the *acquisition metaphor* of learning. She went on to describe a second metaphor, the *participation metaphor* where she defined learning as gaining practices or participating within a social group. Knowledge is not an object that is either in the universe or in someone's head but resides within the practices of a culture or social group.

Interview data. We coded all interview transcripts by first picking out all passages where the participant made reference to how (s)he learned, how students learned, what (s)he considered to be good teaching (whether or not they do it), references to her/his own practice, and any reference to the nature, product, or process of science. We separated these passages from the original transcript and placed them in a table for each participant and by category. We used these groups of statements as proxies for personal epistemology (*how* the participant talked about her/his learning), student epistemology (*how* the participant talked about how students learn or how (s)he had to teach to get students to learn), and scientific epistemology (*how* the participant talked about the nature, product, and process of science).

We then read through the list of passages one category at a time. In other words, for one participant at a time, we looked at the list of passages where the participant referred to his or her personal learning, then student learning, and scientific knowledge development. We identified the passages as invoking either the acquisition metaphor or the participation metaphor of learning. Table 2 gives examples of the types of quotes that were coded acquisition and participation. When looking at the quotes concerning the nature, product, or process of science, we discerned that all participants spoke of science within a range of realism, or objectification of scientific knowledge. At one end of this range was *scientism*. We identified these participants who spoke about unchanging "truths" of nature and how they are discovered through rigidly controlled experimentation (Abd-El-Khalick, 2001). This scientific epistemology is illustrated by the following quote from one of our participants.

"I may test gravity by dropping something all over the world. And someone may test gravity in another way but in the end you're still going to get the acceleration due to gravity that is X amount, whatever that is for wherever you are...And that's why you have to repeat experiments over and over again to see that they actually do agree."

In this view, truths of the world are waiting to be uncovered and only through experimentation can such truths be found, independent of human context. On the other end of the (albeit narrow) spectrum was a more sophisticated form of realism. We identified them as assertions that science provides explanations about phenomena and is subject to change with new observations, as illustrated by this statement:

Table 2. Coding of Interview Data – Beliefs about Learning and Teaching

	Acquisition metaphor	**Participation metaphor**
Personal epistemology	"I **picked** others teachers' brains" "**I have stolen, or borrowed**" ideas from mentor	"On the job **training**" "Not observing, but **really teaching**..."
Student epistemology	"If the students don't **get it** then, they might **pick it up** in review" "Maybe there's a bigger lesson there they can **take** into life..."	"They are learning the methodology because **they are doing it**." "They need to **play** and **work through** the experiments and **actually do** the science rather than read or hear it."
Teaching (good teaching and description of personal practice)	"**Drill it** into their heads" "I try to explain things verbally...visually... demonstrations... so **they get**..."	"Cooperative groups and...**working together** skills" "because it's not really about science content anyways as much as it is about the **processes** of science."

"science knowledge changes...there isn't an authority figure that tells you the answers, you know. What does the evidence show? How do you -- how'd you reach that idea? Is there a better explanation? And working through those processes actually helps the kids understand their own ideas better, rather than just because it said B."

Here, the participant described that although the data point in the direction of the truth, scientists are not privy to all of the evidence at once. Thus science knowledge accumulates gradually.

Video data. As described above, the in-depth participants supplied semiannual videotaped examples of their practice. We viewed from one and a half to four hours of videotaped lessons for each participant. See Table 3 for a breakdown of video durations and topics for each participant. We discerned three major themes of classroom activity. The first we identify as *traditional.* We designated portions of the classroom activities that were both teacher-centered and teacher-directed as being traditional instruction. The second designation was *transitional.* We gave this designation to instances where the activities were student-centered, *viz.* students working together in groups, however the teacher was still directing the activities by providing directions to follow or data to be graphed. In these cases, students, though working together, still did not have the opportunity to explore their own questions, design their own experiments, or collect their own data. The third designation was reform-based. Both student-centered and student-directed activities would have been characteristic of this designation. From an epistemological standpoint, we identified knowledge *transfer* during class activities that were lecture based or had a propensity toward verification. Knowledge *construction* we reserved for instances where students were developing their own path in an investigation and deriving their own data and conclusions.

FINDINGS

Participants from the SPU program (Alexander and Mark). When talking about his experiences in learning what and how to teach, Alexander saw knowledge as a thing that could be "**crammed**"[1] down and "**kicked**" around. This is consistent with the acquisition metaphor of learning. However, he also seemed to describe his learning, or the circumstances by which he could learn through participation as well. Working in groups and trying to understand how a battery worked, Mark enjoyed how "it was really fun to make this guess, explore. Make this guess, explore. Make this guess, explore." He also commented how ideal circumstances would allow more interaction between him and the teacher educators at SPU. He did not elaborate on the nature of the interaction, whether he would acquire more information through this interaction or learn in an apprentice fashion from the other professors.

Mark described his mentor as someone who "**had** very practical ways" of teaching that he got from him. He also asserted that his teacher education program "showed him" the theoretical aspects of teaching. Though he acknowledged that the theoretical ideas were really for the ideal classroom, he did say, "it gave me a good foundation to work from. And then, it **gave me** a foundation to build on." He was very "interested in **building up** the understanding of, maybe, some methodologies and, essentially, teaching." Though he did speak in terms of the acquisition metaphor the majority of the time, he did also reference participation once.

> "I'll tell you the single thing that probably helped me the most was . . . going into a classroom . . . and being responsible for that classroom . . . and setting up everything . . . and doing everything that I had to do as a teacher . . . and learning that process."

Here, it is obvious that Mark saw his own learning resulting form participating in teaching itself and all of the actions involved with it (going, being, setting up, doing, and learning that process). Each participant maintained a pluralistic personal epistemology with emphasis on the acquisition metaphor.

Where both SPU participants spoke in terms of both acquisition and participation metaphors for their own learning, they each maintained a student epistemology that we identify as acquisition. In describing his goal for a particular lesson, Alexander said, "I want my kids **to get this big picture** and that's our goal today… Then we can **put the details in** later." He implied that knowledge garnered from doing an activity was something students would or would not receive. "They were kind of grossed out and they didn't **get a lot out** of the lesson." However, he did assert that once they had the knowledge, they could take it with them out of the classroom – "Maybe there's a bigger lesson there **they can take** into life."

Similarly, Mark spoke of his students' learning in terms of acquiring things. "These are the things I have to cover...I know it sounds terrible but **if the student has it**, great. If they don't maybe we'll **pick it up** in review." He indicated that the best way for transferring information to the students was through an assortment of strategies.

[1] Instances of **bold face text** within quotes alert the reader to what we have identified as the speaker's use of metaphor. We do this because often times our use of metaphor is so common that we do not recognize them (Lakoff & Johnson, 1980)

Table 3.
Video data collected for each participant

TEP	Participant	Video 1	Video 2	Video 3
SPU	Mark 200 min	Fall 2006, two consecutive days, 40 minutes each day Physics - circuits	Spring 2007, Two consecutive days, 60 minutes each day Physics - electricity	
	Alexander 120 min	Fall 2006, 40 minutes Forensics - electrophoresis	Fall 2007, 40 minutes Biology – graphing data	Fall 2008, 40 minutes Biology – vocabulary game
NPU	Erica 240 min	Fall 2008, 120 minutes Biology – ecosystem lab	Spring 2009, 120 minutes Physical Science – density activity	
	Laura 90 min	Fall 2008, 45 minutes Physical science – density activity	Spring 2009, 45 minutes Physical science – science in media activity	
	Christine 160 min	Spring 2008, Two consecutive days, 40 minutes each day Biology – eye anatomy and endocrine system	Fall 2008, 40 minutes Biology – cell structure	
MPU	Courtney 120 min	Fall 2007, 60 minutes Chemistry – Rutherford model of atom	Spring 2008, 60 minutes Physics - circuits	
	Joyce 180 min	Fall 2007, two consecutive days, 45 minutes each day Forensics – crime scene activity	Spring 2008, Two consecutive days, 45 minutes each day Biology – natural selection, genetic drift	

> "I think when you **provide** them with a variety...[of] **ways...to get** the information – like we'll do a lab, we'll do an activity, we'll do notes, we'll do stuff online. So **between those ways**, a student who **doesn't get** the notes - because I'm sitting up there talking to them about it – but they **may get it** when they see a picture or a graph on the computer."

To Mark, knowledge is something that he can give through giving notes or just talking about it and students can get by either hearing it or seeing it.

Alexander and Mark both indicated a scientific epistemology reflecting scientism. This naïve form of realism "grossly overestimates the degree to which the human mind has certain access to the ultimate reality and over simplifies the process" Bickmore et al, 2009, p. 169). Alexander, for instance, considered science as an exploration for ultimate truth when he said, "I think it's that exploration... It's the...desire to, like...find out, and, we're gonna go find out." The way scientists "find out" is through experimentation, or, as put by Mark, "through a rigid system of tests." Neither one indicated a sense of creativity or a process of construction on behalf of scientists. In this way, knowledge is accumulated through experimentation and that knowledge will be verified by further experimentation. Mark, said, "if you're looking at a process that is...a natural scientific process, the rules and the discussion and the results should come out to be the same regardless of how you get there." According to his thinking, there is one universal truth and scientists will find that truth and verify it via experimentation.

Participants from the NPU program (Christine, Laura, and Erica). As was the case with the SPU participants, the NPU participants invoked epistemological pluralism with emphasis on acquisition when describing their personal epistemologies. Comments of participation like this from Christine, "if you get together everyday…And discuss things and do labs together and practice, um, and do different - swap classes in a sense, to swap activities in a class" were rare compared to most comments made in reference to personal epistemology. Instead, the NPU participants implied that they learned through the acquisition of knowledge. They had either "**picked**" the brains of their mentors, had "**stolen**" ideas from them, or described how their methods classes "**gave**" ideas to them.

Also similar to the SPU participants was NPU participants' use of the acquisition metaphor when describing student epistemology. This is how Erica described student learning. "You know, some kids **just soak it in** from others, but, for the most part, um, if I just **give them, like, something**, they can express what they know about it." While Laura would have her students "**drown**" in content by giving them "lab after lab after lab."

We identify scientism as the scientific epistemology for all three NPU participants. Laura, for instance, said that science has a creative aspect to it and scientific ideas are subject to change, however she did not mention where the creative aspect of science comes in and explained the changes in scientific knowledge in terms of new technology able to "see on a smaller and smaller scales, as we can see farther out into space, we know more, we learn more." In other words as we develop better technologies, we are able to view the truth, which is already there, better. She did acknowledge that there was a "human side" of science, but spoke of it as a weakness of science, as scientists need "strive to be objective" or else they "can't be trusted." In general, the NPU participants asserted that it is the process of "rigidly controlled experiments" that results in the knowledge of science.

Participants from the MPU Program (Courtney and Joyce). Based on the interview data from Courtney, we discerned that she maintained a pluralistic personal epistemology, but one that emphasized the participation. Whereas she at times spoke of having her teaching philosophy "**firmly embedded**" in her head, where took certain ideas and "could **mold** them, **bend** them, **change** them and do what [she] need[ed] to do **to fit** that philosophy." She more often spoke that the field experiences were important to her because "you learn so much just by doing." Joyce spoke of her learning only in the context of the participation metaphor. She found her methods classes important to her development as a teacher because, "we always did the inquiry activities ourselves as, ah, students we were allowed to play and see how the kids would experience it when we were working on coming up with inquiry lessons."

We identify Courtney as also having a pluralistic epistemological stance with regard to student epistemology, but with emphasis on students acquiring knowledge over developing knowledge through the participation within a group. For instance, Courtney said, "They [students] are…learning scientific methodology better because they are doing it." However, she more often spoke in terms of "how to **deliver information**" to her students, or how having classroom routines "**takes one more variable out** of their head." Joyce demonstrated that same pattern of description. With regard to her practice, she described the importance of collaborative groups and having students "work through those processes." At the same time, however, she spoke in terms of acquisition when she wanted to "**add a level** of complexity" to their understanding. She also liked for her students to "**organize their thoughts** and **connect things** together," and was at times worried that they "weren't **getting it**."

The MPU participants took a more sophisticated epistemological stance with regards to science than did their counterparts in the two other programs. We discerned a realist epistemology for both Courtney and Joyce, as the both referred to "the finding of knowledge," or that "there isn't an authority figure that tells you the answers." Both participants did emphasize the tentativeness of scientific ideas. Courtney asserted that ideas in science needed to be testable and disproven to change, and that begins with looking at the data or the questions form a different perspective. Joyce suggested that the evidence must support ideas of scientists, with the implication of supporting a created entity versus some reality of nature.

In sum, all but three participants spoke in terms of a pluralistic personal epistemology, utilizing language implying both acquisition and participation metaphors. Though we identified them as pluralistic, all but Courtney emphasized the acquisition metaphor by making many more comments implying knowledge to be a manipulable object. Two participants, Christine and Joyce invoked the participation metaphor solely when describing their own learning. Despite this pluralism in their personal epistemologies, They all spoke most often in terms of students acquiring knowledge. Only the two MPU participants spoke in terms of a pluralistic student epistemology. The SPU and NPU participants also maintained an epistemology reflecting scientism when it came to their understanding of science, where the two MPU participants had a more sophisticated realist epistemology. There is a loose alignment of epistemologies for the SPU participants with even less coherence among epistemologies for NPU participants and decreasing further for the MPU participants. Table 4 gives a summary of epistemologies by participant.

Observed practice. Despite the geographic difference and differences in TEPs, the teacher practice among teacher participants was remarkably similar in structure and emphasis on acquisition metaphor in instructional strategies observed. Classes usually began with an opening question ("do now" or "answer now"). The questions were somehow associated with the content to be discussed that period. Once students had time to answer the question, they were either asked to turn them in, or just put them away. There was no discussion of the answers, nor did students work together to answer the questions. Following this, the teacher most often began lecturing from Power Point slides or overhead projector with a presentation emphasizing vocabulary. In the interview data, many of the participants mentioned the importance of vocabulary within the lesson structure. Students sat passively, taking notes during this time. The lecture portion of class lasted between 5 and 15 minutes. One class, a seeming review, had students playing a game where one would guess a vocabulary word from the clues given by other students. However, the emphasis was not on constructing the proper meaning for the concept, as any clue to stimulate utterance of the appropriate vocabulary word was allowed. The implication being that the meaning is

Table 4.
Participants' Epistemologies Relationships and Classroom Practice

Program	Participant	Personal Epistemology	Student Epistemology	Scientific Epistemology	Classroom Practice
SPU	Mark	Pluralistic/Acquisition	Acquisition	Scientism	Traditional/Transfer
	Alexander	Pluralistic/Acquisition	Acquisition	Scientism	Traditional/Transfer
NPU	Erica	Pluralistic/Acquisition	Acquisition	Scientism	Traditional/Transfer
	Laura	Pluralistic/Acquisition	Acquisition	Scientism	Traditional/Transfer
	Christine	Participation	Acquisition	Scientism	Traditional/Transfer
MPU	Courtney	Pluralistic/participation	Pluralistic/Acquisition	Realism	Transitional/Transfer
	Joyce	Participation	Pluralistic	Realism (two kinds of science)	Transitional/Transfer

Notes:
Acquisition metaphor – "Concepts are to be understood as basic units of knowledge that can be accumulated, gradually refined, and combined to form ever richer cognitive structures" (Sfard, 1998, p. 5)

Participation metaphor – "[L]earning a subject is now conceived of as a process of becoming a member of a certain community. This entails, above all, the ability to communicate in the language of this community and act according to its particular norms. The norms themselves are to be negotiated in the process of consolidating the community" (Sfard, 1998, p.6).

Realism – "Science, especially, was thought to be a system in which only verifiable statements should be allowed...observations are made, hypotheses are formulated, and more observation either verifies the hypothesis or it doesn't. A thoroughly 'verified' hypothesis is then considered correspond fairly exactly to reality" (Bickmore, et al, 2009, p. 169)

Scientism – "Scientific knowledge is not tentative because 'the term science…denotes only knowledge which is sure, certain objective, quantitative and organized or formulated in to laws'…achieved through following the 'steps of the scientific method…' and/or relying on neutral, objective observations of natural phenomena" (Abd-El-Khalick, 2001, p. 221).

Traditional – Teacher-directed and teacher-centered
Transitional – Teacher-directed and student-centered

Transfer – Teaching strategies and activities imply that the teacher imparts content knowledge to the student.

intrinsic to the word. In other words, like the conduit metaphor (Reddy, 1979), if the student gets the vocabulary word, (s)he also gets its meaning.

Subsequent to the lecture portion of class, the teacher engaged students in a worksheet. This happened during lessons on electrical circuits, finding the density of different materials, or graphing ecological data. In all cases, the activities were decidedly teacher-directed. There was no room for input from the students for deciding what or how to investigate the particular concept. The students were left alone to work on the activity and answer the questions at the end of the activity. There were occasions when a second episode of lecture/notes took place. There were two instances where the class ended with a question to answer about the previous work done, but most often the class just ended with no wrap up or tying together of the periods' activity.

In the case of the MPU participants, their classrooms appeared to be more student-centered, in that there was much more group work and much less obvious direct instruction. However, the activities were still very much teacher-directed as if reliant on the transfer of knowledge from teacher to student. Either the teacher gave data for students to graph or apply in a lesson on climate, or she gave answers without discussion, after the activity had concluded. For instance, during an activity to model indirect observation in her chemistry class, Courtney had students roll a marble under a box and record the behavior of that marble if it came back out from underneath. From this data, students were to infer any structures under the box that could affect the marble's direction of roll. Courtney read the directions and then performed a number of examples of how the activity should go. Once the students completed their part, it was Courtney who drew the answers on the overhead projector for each station without asking for student input or generating discussion from the rest of the class.

In other classes students utilized prefabricated forensics evidence to produce a legal case. Joyce, the teacher, gave the evidence to the students; students worked in groups, but not collaboratively as each member had a different "specialty" and did not share ideas among the group. Joyce, in this case, did call "specialist" (fingerprints, blood, DNA, etc.) groups to the front of the room and *told them* how they should use their data for building an argument for the forthcoming "trial." In a lesson on electric circuits, Courtney, said that due to time constraints, he was going to be "**cramming** two days of **material** into one day," again, emphasizing information as a manipulable object.

DISCUSSION AND CONCLUSIONS

Coherence among epistemologies. In looking at all of the participants, there appears to be at least some coherence among epistemologies for the SPU participants, and Erica and Laura, from NPU. We identified each of them as expressing a pluralistic personal epistemological stance with emphasis on acquisition. They also expressed acquisition when talking about student epistemologies and maintained scientistic ideas about the development of scientific knowledge. However, participants described as having a personal epistemology identified as participation (Christine and Joyce) or pluralistic with emphasis on participation (Courtney) still maintained a student epistemology that ranged from pluralistic with acquisition emphasis to purely acquisition. Plus, where Christine described science with an epistemology of scientism, the two MPU participants seemed to hold a more sophisticated view of science.

Tsai (2002) made observations that were similar to this. He looked at beliefs about teaching and beliefs about learning rather than personal and student epistemologies. What he found was that participants who had parallel epistemologies (teaching and learning), had acquisition understandings of teaching and learning (what Tsai identified as 'traditional'). Once the beliefs became more participation oriented (Tsai's 'process'), the coherence between the two became less clear (see also Kang & Wallace, 2005). In addition, participants had a more sophisticated understanding of teaching than they did of learning. In our investigation, participants with the epistemologies identified as acquisition were the most aligned. Those whose personal epistemology we classified as participation showed less alignment among the three epistemologies; generally having less sophisticated beliefs about student learning and the nature of scientific knowledge.

It seems intuitive that epistemologies should align, at least somewhat. For instance, if someone considers knowledge as being objective, and separate from the knower, or "propagated stuff" (Christodoulou, et al, 2010), then he or she should speak of it across all epistemologies: "I **picked** her brains." "If they don't **get it** now, maybe they will **pick it up** in review." Science is "a systematic way for **acquiring knowledge** and information." However, this "nestedness" (Tsai, 2002) is not representative of the data. The literature also describes epistemological pluralism as being more common (Bryan, 2003; Hodson, 1993; Kang & Wallace, 2005; Kinchin, 2009). To us, this indicates that instead of starting with an understanding of what knowledge is and then applying it to her/himself, and her/his students and science, (s)he maintains separate understandings of the self, students, and science, and develops an embodied (Lakoff & Johnson, 1980) understanding of what knowledge is within the context of each facet of the participant's environment.

For instance, each of the teacher education programs has at least some field experience component within it. This is the opportunity for students of teaching to practice their craft. Each of the participants in the study spoke of their own learning, at least in part, with language indicating participation metaphor of learning. In addition, MPU participants, having about 800 hours of teaching field experiences (as opposed to the approximately 300 hours in the SPU program), were much more likely to emphasize participation in their learning, even to the exclusion of acquisition learning.

However, despite the more sophisticated understanding of their own learning, all participants continued to utilize language emphasizing the acquisition metaphor in reference to how their students learn. An explanation for this could actually lie within the language itself (Lakoff & Johnson, 1980). Reddy (1979), studying metaphorical structure in language, described what he referred to as the conduit metaphor of language. He put forth evidence that English speakers' talk about communication is "largely determined by the semantic structures" (p. 285). He claimed that when we speak about language we do it in a way that views ideas as objects, linguistic expressions as containers and communications as sending the objects via the containers.

- Idea as object: Try to get your thoughts across better. You still haven't given me any idea what you mean (p. 286, emphasis in original).
- Linguistic expressions as containers: You have to put each concept into words very carefully. Try to pack more thoughts into fewer words (p. 287, emphasis in original).
- Communication as sending: That concept has been floating around for decades. Somehow these hostile feelings found their way to the ghettos of Rome (p. 291, our emphasis).

Reddy explained that these semantic structures draw us into the notion that there is an expenditure of energy during the communication and that energy is spent by the communicator, trivializing the function of the reader or listener. However, the "readers and listeners face a difficult and highly creative task of reconstruction and hypothesis testing...[that] requires more energy than the conduit metaphor would lead us to expect" (p.309). This idea is relevant here as teaching is a form of communication. Understanding how to do it effectively may come down to how it is perceived by both teacher and student. This understanding could very well be influenced, unknowingly, by the metaphors we use in our everyday language. However, the extra hours of teaching practice for the teachers in the MPU program may have afforded enough experience of participation to supplant the metaphor of acquisition with regards to their personal epistemology.

We posit that the scientism implied by the participants' comments have their foundation within the conduit metaphor as well. Participants objectified scientific knowledge; a "thing" external from the mind. It was their "extensive experiences with physical objects that [was] the basis for viewing non bounded concepts (events, activities, ideas, etc.) as objects creating ontological metaphors" (Lakoff & Johnson, 1980, p. 25). Accordingly, scientific ideas are objectified as something that can be verified through "rigid and controlled experimentation." Our participants showed a subtle difference in sophistication in their epistemologies. Participants from the SPU and NPU programs experienced little formal NOS instruction compared to those from the MPU program. SPU student teachers may or may not have experienced explicit NoS instruction within their methods class. The NPU program maintained a standalone NoS course offered as a two-week course in the spring prior to student teaching. The MPU program had two, semester-long NoS courses and required two additional semesters of applications of science courses. The applications of science courses were heavily inquiry-based methods courses for each of the four specific content domains (biology, chemistry, earth science, and physics). The entire MPU program was also structured under the umbrella of Science, Technology, and Society (STS) (Pinick & Yager, 1997), creating a coherent context for explicit and implicit NoS instruction (Ab-El-Khalick & Lederman, 2000).

Relationship between beliefs and practice. The idea of connecting teacher beliefs about science, learning and teaching to teacher practice has become a *holy grail*, of sorts, for science educators. It is connecting what can be observed to something that can only be inferred. Many have expressed the importance of this connection. "Science teachers' epistemologies – which include beliefs about science, beliefs about teaching science, and beliefs about learning science – affect the type of instructional behaviors that occur in science classrooms" (Jones & Carter, 2007, p. 1075). "[W]e wonder whether individual beliefs about the nature and justification of historical knowledge influence history teachers' pedagogical choices" (Maggioni et al., 2009, p. 188). "It seems self-evident that teachers' own views about the nature of science and scientific inquiry will influence substantial aspects of their professional practice, including decisions about the design of learning experiences"(Hodson, 1993, p. 41)."[T]he constructivist-oriented SEVs [scientific epistemological views] appeared to foster the creation of more constructivist-oriented science learning environments" (Tsai, 2007, p. 222, our bracketed addition). Indeed the vast majority of investigations seeking the relationship between teachers' beliefs and practices did so because "the next issue educators face is how to change teachers' 'traditional' beliefs about teaching, learning and science" (Tsai, 2002, p. 780).

When trying to discern a connection between teachers' beliefs and their classroom practice, we can infer from our data that the direct expression of beliefs in practice, as many have asserted, is not obvious at all. The practices of all of the participants incorporated some mode of information transfer from teacher to students. This may have been in the form of direct lecture, notes or guided notes, the teacher telling students how to perform an activity or giving the data that students were "suppose to get." None of the observed lessons contained opportunities for students to direct their own investigations, formulate their own questions, or make their own predictions. The lessons done by the SPU and NPU participants were also very teacher-directed. The teacher explicitly led the activities done in class. The MPU participants may have instituted activities that incorporated more student group work, but in the cases observed, members within groups had distinct and individual responsibilities, making any kind of collaboration or community learning very difficult. Even though the MPU participants and Christine (from NPU) spoke of their own learning in terms of them actually doing it, and figuring it out for themselves, and/or collaborating with their colleagues, *they did not* promote this model of learning with their students.

Misalignment between beliefs and practice has been noted in other literature (Hodson, 1993; Kang & Wallace, 2005; Lederman, 1999; Salter & Atkins, 2014; Tsai, 2002; Waters-Adams, 2006). As a way to explain this misalignment and still maintain the directionality of beliefs influencing practice, authors have invoked mediating factors, such as tacit beliefs (Waters-Adams, 2006), teaching context (Hodson, 1993; Jackson, 2011), goals and intentions (Lederman, 1999), difficulties enacting beliefs (Hanuscin, 2013), existing occupational culture (Schemp et al, 1993), and knowledge structures not being integrated (Bartos & Lederman, 2014).

Instead of invoking various mediating circumstances to make sense of data when looking from the perspective of beliefs influencing practice, we posit a different explanation; looking at the data from a different perspective. For example, we could supplant teacher beliefs with teacher actions as the starting point and look at the data as though the actions of the teacher developed the beliefs they have. Waters-Adams (2006) hinted at this in his study, saying,

> "the intuitive appeal of the idea that the existence of a relationship must mean a causal influence, running from understanding to action, is weakening…What this study has reinforced, however, is that understanding at a theoretical level does not predict eventual practice. It is only one element of a web of influence on action and, quite probably, is not the most important. (pp. 939, 941)"

What Waters-Adams proposed in his paper is that theoretical understanding may come from the actions of teaching rather than the other way around, as is the consensus view.

If we frame the data this way, there is less need to force the issue with such mediating factors as listed above. The rationale for this change in perspective comes from the theory of sociocultural learning. According to this tradition, the learning happens by doing. The unit of analysis is not the individual but the activity of the group the individual belongs to (Driscoll, 2005). It is the participation of the teacher within the culture of teachers, which is the learning and successful completion of the tasks of the group will affect the beliefs of the individual during the development of shared meaning (Driscoll, 2005).

In other words, our teacher participants used standard transfer strategies in their teaching and therefore saw their students as recipients of that knowledge, though they did not view their own learning in such a way. They utilized teacher-directed, confirmatory activities as a way to teach content, reinforcing beliefs that rigidly controlled experimentation will ultimately confirm the facts of the natural world. With more, and integrated NoS instruction in their TEP, teachers were more likely to view NoS content as integral to science content (Barry, Tillotson, & Young, in prep). The teachers learned to teach by participating in student teaching and those with more participation (MPU) described their learning with more emphasis on participation.

Lest it seem, however, that we wish to swing the pendulum of focus completely to the side of behaviorism, it is not the case. We pose it as alternative way to approach the question. Another possibility, more of a Buddhist "middle path", would be from a holistic frame of reference. Korthagen (2004) proposed such a model. In his report, Korthagen described teachers in terms of layers of influence in a sort of "onion model." In his model, the onion starts at the core with *mission*, and progresses to the exterior with layers identified as *identity*, *beliefs*, *competencies*, and *behaviors*. Exterior to the "onion" is the *environment*. Korthagen proposed that external layers could work to change or reinforce successive interior layers, while at the same time the interior layers could also work on or influence successive external layers.

In this model, beliefs can be influenced by the environment, behaviors and competencies, but they also answer to the identity and mission of the teacher. If an environmental condition evokes a behavior that seems to be successful, this behavior can become a competency with an associated belief that it is successful. However, the mission and identity of the teacher can also guide behavior. These characteristics are so deep within the teacher that they are fairly stable from change. And, though stable, identity may manifest, not as a static role, but in more fluid *positions* (Davies & Harre, 1990) that are different enough to evoke different behaviors based on different situations. For instance, when asked what his role was as a teacher, a participant stated that he felt like he was a "facilitator," but sometimes felt like a "teacher." This teacher did not, as Korthagen would put it, "see" a teacher's position as a facilitator. He saw himself with two different sets of behaviors within the identity of educator. He claimed to be a facilitator in response to certain circumstances and a teacher during others. The connection between belief and practice in Korthagen's (2004) model is much more dynamic, even iterative, where discerning either one becomes more like shooting at a moving target. This is not to say that it is an impossible task, though certainly more complicated. It means that more needs to be taken into account if the beliefs and practice knowledge base is to bear fruit more expeditiously, and if teacher education programs are going to be able to make a difference in the mission, identity, and beliefs of teachers rather than just the competencies and behaviors, before letting them go and become the agents of change they are meant to be.

IMPLICATIONS

Maintaining a more complicated model of teacher education will have profound implications of the structure and content of TEPs. The current structure, with many of the early courses devoted to theories and philosophies of teaching and learning, emphasizes belief change (or enhancement) first, with student teaching normally taking place within the last two semesters of the program. The program is set up to emplace the appropriate beliefs into the teacher and then send her/him out to enact those beliefs. With our more complicated model, this sequence is not very effective. A student teacher can know all of the benefits of reform based teaching, but if they had experiences of traditional teaching as a student, or their host teacher is a traditional teacher, transferring knowledge to her/his students and encouraging the student teacher to do the same, it only makes sense that the student teacher will come to believe in the efficacy of traditional teaching.

Instead, teaching should start right away, be extensive, happen in an environment where the desired practices are supported, and be *concurrent* with methods classes. The bottom line is that the entire program should be integrated with all facets (cognitive, social, theoretical, philosophical and practical) of the environment supportive to the type of teaching desired. This is the future work of university science educators. They must restructure and TEPs to take into consideration a more dynamic relationship between teacher beliefs and practice.

Where teacher educators have at least some control over the university portion of the program environment, they have less control over the practicum environment. Since the passage of such legislation as *No Child Left Behind*" and more recently, "*Race to the Top,*" so much emphasis is now placed on accountability and high stakes testing. Potential mentor teachers are feeling the pressures of testing and succumbing to the "teach to the test" attitude. This makes finding teachers who are willing to support young teachers with their reform-based teaching agendas an increasing challenge. In addition, the current movement to tie student test scores to teacher evaluations will most likely have a similar effect. Teachers are less likely to want to give up control of their classes to a student teacher with an unknown teaching record. If they do take a student teacher, they may be much more apt to promote or direct student teachers into a very traditional, transfer model of teaching.

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