Personal epistemology in pre-service teachers: Belief changes throughout a teacher education course

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Introduction

Classrooms of the 21st century are complex systems. They support diverse learners from varied contexts and function in a "messy" bricolage of policy contexts. This complexity is also evident in the nature of teaching and learning deployed in these classrooms. There is also, in current contexts, a general expectation that teachers will support students to construct, rather than simply receive knowledge. This process of constructing knowledge requires a focus on critical thinking in complex social and real world contexts (see also Elen & Clarebout, 2001; Yang, Chang & Hsu 2008). Critical thinking, which involves the identification and evaluation of multiple perspectives when making decisions, is a process of knowing – a tool of wisdom (Kuhn & Udell, 2001). Schommer-Aikens, Bird and Bakken (2010) refer to classrooms that encourage critical thinking as "epistemologically based" in which "the teacher encourages his/her students to look for connections among concepts within the text, with their prior knowledge, and with concepts found in the world beyond themselves" (p. 48).

In dealing with complex problems it is important, therefore, that knowledge processes, not just knowledge products, are focused on in learning settings. Beliefs about knowing and knowledge held by individuals (personal epistemology) are central to development of knowledge processes, such as critical thinking (Kuhn & Udell, 2001). Despite this recognized link between knowledge and personal epistemology, the understanding has yet to make a great impact on teaching and learning in teacher education. In the current study, we are interested in understanding more about preservice teachers' personal epistemologies and how beliefs change as individuals progress through their teacher education programs. This is an area of research that has received very little research attention and yet may "provide an important theoretical basis for education as well as teacher training and development" (Bendixen & Feucht, 2010, p. 7).

The meaning of personal epistemology is debated and can be influenced by the approach from which it is studied. Different approaches may refer to personal epistemology as stages, levels, beliefs, reflections, theories, ways of knowing, metaknowing and resources (Hofer, 2004a; 2004b). A

common theme amongst these views is that personal epistemology relates to an individual's thinking about knowing and knowledge (Pintrich, 2002).

Kuhn and her colleagues (see Kuhn, Cheney & Weinstock, 2000; Kuhn & Weinstock, 2002) described a trajectory of personal epistemology. They described the development of personal epistemology from *absolutist* (knowledge as absolute and transferable), to *multiplist* (knowledge based on personal opinions), to *evaluativist* (knowledge based on judgments of evidence from multiple perspectives) (Kuhn & Weinstock, 2002). Of interest here is the role played by critical thinking in each of these levels. Clearly if "reality is directly knowable" (Kuhn et al., 2000, p. 311) (the Absolutist) or personally created (the Multiplist), critical thinking is not central. In these early levels there is no need to evaluate multiple perspectives in order to arrive at an evidenced-based outcome. In contrast, we believe that teachers need to engage in critical thinking in order to promote effective teaching and learning in diverse communities of learners.

Personal epistemology and pre-service teachers

Personal epistemological beliefs affect learning and influence the extent to which understanding is developed and meaning is made (Hofer, 2002). There is strong evidence to show that pre-service teachers' personal epistemology influences their learning strategies and learning outcomes (Muis, 2004). That is, we know that personal epistemologies filter how pre-service teachers experience learning in teacher education courses (Many, Howard & Hoge, 2002; Muis, 2004; Peng & Fitzgerald, 2006; Yadav & Koehler, 2007) and engage in meaningful approaches to learning (Muis, 2004). These meaningful approaches to learning are described as deep-holistic learning strategies (Ramsden, 2003 in Thomas, Pligrim & Oliver, 2005) and reflect qualitative conceptions of learning (Marton, Dall'Alba & Beaty, 1993). Such strategies focus on building personal meaning and organizing ideas so that links are made to prior knowledge, connecting ideas and evaluating a range of evidence (critical thinking). On the other hand, surface-atomistic strategies focus on the surface-level literal meaning with few interconnections made between topics and theories. Often this results in rote learning (Ramsden, 2003 in Thomas, Pilgrim & Oliver, 2005) and may reflect quantitative conceptions of learning (Marton, Dall'Alba, & Beaty, 1993).

A number of studies have shown that sophisticated personal epistemologies are related to meaningful approaches to learning. Bondy et al., (2007) investigated how personal epistemologies were related to preservice teachers' approaches to learning by analysing data based on interviews with 14 preservice teachers. These researchers also found a relationship between personal epistemology and approaches to learning whereby preservice teachers with sophisticated personal epistemologies (knowledge is uncertain and integrated) were more likely to be open to multiple perspectives and to

make connections between ideas. Brownlee et al., (2002) also found similar relationships in a group of early years teachers in Australia. Teachers who described evaluativistic patterns of beliefs also described deeper approaches to learning where connections were made between new and prior knowledge. Some research also suggests that personal epistemologies may be related to levels of critical thinking, a dimension of meaningful approaches to learning. Braten and Stromso (2006a) showed that 1st year Norwegian pre-service teachers' personal epistemologies about the speed of knowledge acquisition influenced their capacity to engage in critical thinking in the context of evaluating Web-based resources. Muis (2004) described these personal epistemologies as *availing* because their personal epistemologies were supportive or availing of deep approaches to learning.

Collectively, these studies demonstrate that personal epistemologies influence learning in terms of students' beliefs about learning and this is clearly an important body of research for understanding how pre-service teachers navigate their teacher education courses and develop a sound body of knowledge and skills for entry into the teaching profession. However, we still know very little about how pre-service teachers' personal epistemologies change as they progress through their teacher education programs. While there are no longitudinal studies to date, Bendixen and Corkhill (in press) investigated personal epistemologies in teachers at various stages of their professional journeys. Using a cross sectional research design, they examined personal epistemology in beginning and final year pre-service teachers, as well as beginning and experienced in-service teachers. Their study showed that beginning pre-service teachers tend to have more naïve beliefs regarding the certainty and simplicity of knowledge, but more sophisticated beliefs about the nature of innate intelligence (incremental view of intelligence) when compared to experienced teachers. Brownlee (2003) also investigated changes in pre-service teachers' personal epistemologies as they completed a one year Graduate Diploma in Primary teaching and progressed into their teaching careers. Twenty-nine pre-service teachers were interviewed at the beginning and end of their teaching course and then eleven teachers were re-interviewed in their third year of teaching. Over the three time phases, seven teachers described more evaluativist personal epistemologies, two remained the same and two regressed to more objectivist personal epistemologies. However, the process of changing epistemological beliefs of pre-service teachers as they progress through their teacher education course was not addressed in this study. Thus, the current study will provide the first longitudinal data of changes in personal epistemologies for pre-service teachers.

The study

Given the research evidence showing that personal epistemology influences learning, this study investigated a) the relationship between personal epistemologies and beliefs about learning and b)

changes in personal epistemology and beliefs about learning for a group of early childhood and primary pre-service teachers as they progressed through the first three years of a four year Bachelor of Education. The study reports on two phases of data collection that track pre-service teachers through their four year teacher education program. A final phase of data collection will take place in 2010 as these pre-service teachers complete the fourth and final year of the teacher education program. It is anticipated that this final phase of data will provide additional evidence of change in personal epistemology and beliefs about learning which can be used to inform teacher education programs.

Participants and Context

Pre-service teachers in the Bachelor of Education (Early Childhood) undertake a full-time internal degree, which is recognised by the Queensland College of Teachers as meeting the requirements for Queensland teacher registration. The degree prepares pre-service teachers to teach in prior-to-school contexts as well as in the first three years of school. Practicum is undertaken in semester one and semester two of the second year, semester one of the third year and semester two of the fourth year. Phase one of the data collection occurred at the beginning of 2007 while phase two of the data collection (epistemological belief questionnaires and interviews) occurred at the beginning of semester 1, 2009. At this point in time, pre-service teachers had completed two practicums and were preparing to undertake a third.

Pre-service teachers in the Bachelor of Education (Primary) undertake a full-time internal degree that will lead to registration as a teacher in Queensland. The degree prepares pre-service teachers to teach school aged-children from the Preparatory Year (aged 5.5 years) through to Year Seven (aged 12.5 years). Practicum is undertaken in semester one of the second year, semester two of the third year and semesters one and two of the fourth year. At the time of Phase two data collection, pre-service teachers had completed one practicum and were preparing to undertake a second.

The Epistemological Beliefs Survey

Pre-service teachers were invited to complete the Epistemological Beliefs Survey (EBS, Kardash & Wood, 2000) in 2007 when they commenced their course (Phase 1) and then again in 2009 when they were in the 3rd year of their course (Phase 2). Phase 1 data collection occurred in the first week of the 2007 academic year for all pre-service teachers (194 Early Childhood Education students; 136 Primary Education students), while Phase 2 data collection occurred in week 1 of semester 1, 2009, for the Early Childhood Cohort ($n = 80$) and in week 1 of semester 2, 2009, for the Primary Cohort ($n = 131$).

The EBS assesses student beliefs about the structure of knowledge (integration of knowledge), speed of knowledge acquisition (learning is quick or not at all), knowledge construction (learning takes place through a process of constructing personal meaning), characteristics of student success (e.g., views about innate ability), and attainability of truth (the certainty of knowledge). Responses are scored on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Following Kardash and Wood (2000), items were summed for each subscale to produce factor scores for Structure (α = 0.74), Speed (α = 0.69), Knowledge Construction (α = 0.62), Success (α = 0.60), and Truth (α = 0.54). Higher scores on all factors represent more sophisticated beliefs.

Semi-structured interviews

On completion of the survey, randomly selected pre-service teachers were invited to participate in Phase 1 follow up interviews. Fifteen early childhood and 14 primary pre-service teachers participated in the Phase 1 interviews. In Phase 2, eight early childhood and five primary pre-service teachers (a total of 13 students) were re-interviewed. Interview responses at Phase 1 and Phase 2 were compared to establish the extent to which changes had taken place in the pre-service teachers' personal epistemologies over time. Interviews were conducted by a research assistant who was provided with interview procedure training. The audio-taped interviews were semi-structured, scenario based and ranged from 30 to 60 minutes in length.

The study used scenario-based interviews adapted from the work of Stacey et al., (2005) to encourage reflection and to facilitate clear articulation of personal epistemologies within the context of the pre-service teachers' fields of study. While the scenarios were varied to reflect the teaching experiences typically encountered by both early childhood and primary pre-service teachers, the questions relating to the scenarios remained similar. Specifically the scenario for both groups of students involved a literacy teaching experience. Students were presented with a situation in which a pre-service teacher was confronted with an experienced teacher enacting pedagogy that was not considered to be best practice in literacy teaching.

The interview questions, based on Hofer and Pintrich's (1997) epistemological framework, focused on beliefs about knowing and beliefs about knowledge. Beliefs about knowing, and how experts are used in student's learning, were sought by asking ''Do you trust the opinions of experts?'' The questions: ''Sometimes people talk about there being 'right answers' or 'truth'. What are your views?''; ''Do you agree with the idea that there are no right answers?'' and ''Do think that anybody's opinion is as good as another's?'', were asked to access pre-service teachers' beliefs about knowledge. The questions about learning were: "How do you go about learning?", "How do you know when you have learnt something?"

The interview transcripts were examined using content analysis for ''patterns, themes, biases and meanings'' (Berg, 2007, p. 304). Well defined categories of personal epistemology have been developed through traditions of research. Thus, a theory-driven approach (deductive approach) was used to categorise the interview responses; Kuhn and Weinstock's (2002) categories were organised into an analytic rubric. Categorisations included: objectivism, subjectivism and evaluativism. The categories of beliefs about learning were analysed deductively using Marton, Dall'Alba and Beatty's (1993) qualitative and quantitative conceptions of learning. Though the researchers were guided by a deductive approach, they were aware that variations could appear as categories were applied. These categories and variations are presented in Tables 1 and 2.

Table 1.

Categories of personal epistemology and examples of participant responses

Personal epistemology	Example participant responses
Objectivism • very limited analysis evident • expert opinions often unquestioned	Me, I think I try what the research says because they have done the research, yeah. (Do you trust the opinions of experts such as your university lecturers and researchers?) Yeah, I think I try almost everything but sometimes I will be oh maybe it's true. Sometimes I can doubt a little bit or I can't really trust everything. Think I just learn from the research yeah and I generally believe all of books they have – they all can help children with their literacy. (Tania)
Subjectivism • knowledge based on personal opinions	Everyone does have their own opinion and are entitled to it. (Wendy)
Practical evaluativism • evaluate & critique a range of observable teaching strategies	Say if someone says the best thing for Daniel is to have the mum, the teacher and Daniel interacting, but then say Daniel might have gone through a tough time with his family during that morning. So you can deal with things differently. Use that information but then use your own knowledge and your own experiences. Maybe build on their knowledge (Wendy)
Complex evaluativism • knowledge evolving & context-dependent. • constructed & open to critique. • evaluate a range of perspectives including theory	Difference between respecting someone and someone's right to have an opinion and valuing their right to have an opinion versus respecting the opinions that they come out with. Also, I think, opinions are there to be questioned and people should be free to share their opinions in a way that encourages them to share opinions. But also in a way that encourages them to question their opinions. Readings from the experts, but they're all just someone's opinion backed up by case study…I just know how many readings that we've done in uni that haven't correlated to each other and that have completely different views on things. So I guess you just want to be well aware of all the stuff out there. (Jordan)

Table 2.

Categories of beliefs about learning and examples of participant responses

Beliefs about learning	Example of participant responses
Quantitative • absorb information from an external source • intention of reproducing the information at a later date	I know when I've learnt something if someone is talking about a certain subject or a question and I can answer it confidently without questioning anything in my head and I know that I've learnt it (Clare)
Application • intention of reproducing or applying the information	I think that it's acquiring knowledge about certain things and being able to use it confidently in the right sort of contexts. So gathering together knowledge and being able to speak confidently to someone about it, being able to write something you know (Clare)
Qualitative – sense making • simple level of understanding • make sense of the task or text • no analysis of perspectives for meaning	…Going over it, and over it, and over it. And writing it, and putting it into my own words so that I understand if it is something that is totally going over my head and lots of big words. Actually breaking it down and putting into my own words, and giving myself an example of it. Like how that would actually work in practice. (Mia) So I guess I would kind of relate it to things that I know because my memory about children sticks in my head because I've related them to someone or something. (Sam)
Qualitative • active role in own learning • analyzing many points of view • collaborate with others	Talk with others. Share our ideas with friends, people in my course and with that you can have kind of an understanding if you don't understand, then having an understanding to begin with and that gives you the opportunity to further research and look at other books and a variety of things [multimodal things] to kind of have another understanding and grasp the whole subject, but yes most importantly how I learn is by sharing and being able to communicate with others and having their ideas and my ideas and having a group understanding (Wendy)

To ensure the consistency of coding, a 'double coding' (Miles & Huberman, 1994) approach was taken. The use of 'double coding' assists in ensuring the rigour of the analyses and the reliability of interpretations from the data (Ming Wen et al., 2002). At both Phase 1 and Phase 2, 25% of the transcripts were cross-checked by a second researcher. The second researcher interrogated the category descriptions and the quotes exemplifying each category. Initial agreement was 66% for Phase 1 and 88% for Phase 2. Points of difference mainly occurred when data sets showed evidence of multiple categories and discussion centred on which category best suited. When responses could be categorised in multiple ways, the highest category in evidence was recorded. All points of difference in the coding were discussed and 100% agreement was reached. Agreement was measured by the extent to which the upper level of coding was evident. For example, if one researcher indicated a response provided evidence of complex evaluativism and practical evaluativism and another researcher only believed it represented complex evaluativism, then the upper level of complex evaluativism was considered to be the key point of agreement.

Results

Changes in personal epistemology

Paired sample t-tests were used to examine changes in pre-service teachers' personal epistemology over time from Phase 1 to Phase 2. Means and standard errors for each of the sub-scales are presented in Table 3. Overall results indicated that there were significant differences between Time 1 and Time 2 on the subscales of Speed, t (136) = -4.17, p = .000, Structure, t (136) =-2.48, p=.015, and Truth, t (138) =-2.03, p=.044, indicating that pre-service teachers evidenced more sophisticated epistemological beliefs on these dimensions in the 3rd year of their course than in the 1st year of their course. Specifically, results indicate that 3rd year pre-service teachers were more likely than 1st year pre-service teachers to believe that learning might take time, that knowledge is integrated rather than consisting of a series of facts, and that knowledge is uncertain. There were no significant differences between Time 1 and Time 2 on the subscales of Knowledge Construction, t (136) =.698, p=.49, or Success, t (138) =-1.06, p=.29, indicating that 3rd year pre-service teachers were no more likely than 1st year pre-service teachers to view knowledge as personally constructed or to believe that the characteristics of successful students include more than innate ability.

Table 3.

Means and Standard Errors for the Sub-scales of the EBS

	Time 1 M (SE) (*N* = 330)	Time 2 M (SE) (*N* = 211)
Speed	4.01 (.03)	4.16 (.03)***
Structure	2.90 (.04)	3.00 (.05)*
Construction	3.69 (.05)	3.66 (.03)
Success	3.61 (.04)	3.67 (.05)
Truth	3.43 (.06)	3.56 (.06)*

Note: *** indicates $p < .001$, * indicates $p < .05$

The interview analysis also revealed changes in personal epistemology from Time 1 to Time 2. Table 4 shows that the majority of pre-service teachers interviewed (*n*=10) evidenced change towards more sophisticated personal epistemology over time. Of these pre-service teachers, four described practical evaluativistic beliefs at Time 1 and then complex evaluativistic beliefs at Time 2. The remaining six pre-service teachers moved from subjectivist to evaluativistic beliefs (*n*=2 complex evaluativism; *n*=4 practical evaluativism) at Time 2. Only three pre-service teachers did not demonstrate any changes, and of these, one pre-service teacher already held sophisticated beliefs at Time 1, suggesting that further development would not be likely to take place over time due to a

ceiling effect This means that only two pre-service teachers who were interviewed at Time 2 held naïve personal epistemologies which did not change over time.

Table 4.

Changes in personal epistemology from Time 1 to Time 2 interviews

Time 1	Time 2	Frequency
Increased sophistication		
Practical evaluativism	Complex evaluativism	4
Subjectivism	Complex evaluativism	2
Subjectivism	Practical evaluativism	4
TOTAL Increased sophistication		10
No change		
Subjectivism & Objectivism	Subjectivism & Objectivism	2
Practical & Complex evaluativism	Practical & Complex evaluativism	1
TOTAL No change		3

Changes in beliefs about learning

Changes in beliefs about learning were also evident in the interview analysis. Table 5 shows that many pre-service teachers (*n*=7) demonstrated changes towards qualitative beliefs about learning.

Table 5.

Changes in beliefs about learning between Time 1 and Time 2 interviews

Time 1	Time 2	Frequency
Increased sophistication		
Quantitative	Quantitative & application	1
Quantitative	Qualitative	3
Quantitative	Qualitative sense making	2
Qualitative sense making	Qualitative	1
TOTAL increased sophistication		7
No change		
Quantitative	Quantitative	1
Qualitative sense making & application	Qualitative sense making & application	1
Qualitative	Qualitative	3
TOTAL no change		5

Note: One not codable for changes over time

Of these, one student moved from a sense making view of learning to a qualitative perspective and one student moved from quantitative to application. Five pre-service teachers did not change their

beliefs over time, although it should be noted that three of these pre-service teachers already held qualitative beliefs at Time 1.

Relationship between personal epistemology and beliefs about learning

The next aspect of the data analysis involved looking at each individual's interview to investigate if there was a relationship between their personal epistemologies and beliefs about learning. This involved analysing what each individual had to say about learning and knowing at Time 2 and reporting on this relationship as described in Table 6.

Table 6.

Relationships between individuals' personal epistemology and beliefs about learning

Personal epistemology	Beliefs about learning	Number of students
Subjectivism	Quantitative/application	1
Subjectivism	Quantitative	1
Practical evaluativism	Qualitative sense-making	2
Practical evaluativism	Quantitative/application	1
Complex evaluativism	Qualitative	6
Complex evaluativism	Quantitative/application	1
Complex evaluativism	Qualitative sense-making	1
TOTAL		13

The data in Table 6 show that a relationship exists between personal epistemology and beliefs about learning which will be discussed. Complex evaluativistic beliefs were associated with qualitative conceptions of learning, practical evaluativistic beliefs were linked with qualitative sense-making and application and subjectivist beliefs were related to quantitative conceptions.

Discussion

Changes in Personal Epistemologies

Both the quantitative and qualitative data indicated that there were changes in pre-service teachers' personal epistemologies between course entry and the third year of their course, thus reflecting a move towards more sophisticated understandings about the nature of knowing and knowledge. With respect to the quantitative survey data, results indicated that 3rd year pre-service teachers were more likely than 1st year pre-service teachers to believe that learning might take time, that knowledge is integrated rather than consisting of a series of facts, and that knowledge is uncertain. The higher scores on the dimensions of structure, truth and speed of knowledge acquisition may indicate that as the pre-service teachers progress through their degree they perceive knowledge as integrated, truth as not absolute but changing and to believe that knowledge acquisition takes time compared to when

they commenced tertiary study. These findings are supported by previous research which has indicated that educated individuals are more likely to be reflective about multiple perspectives, remain open to new information and develop a personal, evidence-based opinion (see e.g.,Baxter Magolda & Terenzini, 2004; Jehng, Johnson & Anderson, 1993; Schommer, 1998).

The qualitative data provide a complementary perspective on the changes in personal epistemologies associated with engaging in preservice teacher preparation at the tertiary level. Specifically, the interview data indicated that the majority of pre-service teachers demonstrated a change towards more sophisticated personal epistemologies over time, moving from subjectivist/ practical evaluativistic beliefs at Time 1 to more complex evaluativistic beliefs at Time 2. Importantly, these changes may be related to more effective, deeper approaches to learning.

Relationships between personal epistemology and learning

The noted changes in personal epistemologies from Time 1 to Time 2 are mirrored in qualitative changes in personal beliefs about learning. The data indicated that more complex evaluativistic beliefs were associated with qualitative conceptions of learning and that there were changes across both these dimensions from 1st to 3rd year of the teacher education course. Thus, as pre-service teachers' personal epistemologies became more sophisticated, there appears to be a corresponding change in their beliefs about learning to more qualitative conceptions. Pre-service teachers with a more sophisticated personal epistemology viewed learning as qualitative in nature, meaning that they sought multiple perspectives in their quest to make personal meaning. Pre-service teachers with subjectivist beliefs view personal learning as reproductive in nature. This is of concern as such beliefs can influence their ability to engage in critical thinking often encouraged in higher education. This area of concern raises questions about the scope of the current teacher education program to shift firmly embedded subjectivist beliefs.

Such findings are in-line with prior research which describes epistemological belief structures as based on a relationship between core and peripheral beliefs (Brownlee, Boulton-Lewis & Purdie, 2001). Core beliefs about knowing reveal core values that are interconnected with other beliefs, such as peripheral beliefs about learning. The findings of the present study support the notion that a relationship exists between core and peripheral beliefs.

Implications for teaching and teacher education

These findings are of importance when we consider that the core business of teachers relates to learning and knowing. Teachers with more sophisticated personal epistemologies and beliefs about learning are likely to be able to engage in complex problem solving tasks, and argue based on evidence for a "best" solution. This is an important skill for any workplace environment, especially

in complex teaching environments. However, while sophisticated personal epistemologies may be an important goal for teacher education programs, often pre-service teachers who finish their courses and enter the profession still hold relatively naïve personal epistemologies (White, 2000). Wilson (2000) noted that teachers with four-year degrees or less were more likely than teachers with graduate qualifications to hold objectivist personal epistemologies in teaching. This means that teaching is more teacher-centred and transmissive, with less focus on student engagement in the process of learning. Joram (2007 in Olafson et al., 2010) also showed that pre-service teachers and beginning teachers were more likely to hold objectivist personal epistemologies than experienced teachers. Our data do not support these previous findings, with many pre-service teachers showing growth in their personal epistemologies by half way through their teacher education course. However, we need to know what happens once teachers enter the beginning years of teaching. These variations in personal epistemology from pre-service teachers to beginning teachers would be significant for helping us to understand teachers and teaching.

Teacher education programs need to assist pre-service teachers to promote sophisticated personal epistemologies and qualitative conceptions of learning (see for example, DeCorte, Op't Eynde, Depaepe, & Verschaffel, 2010). This draws attention to a need to help pre-service teachers to reconstruct personal epistemologies. Such reconstruction may be possible through a focus on explicit reflection on personal epistemologies (Valanides & Angeli, 2005). Though there is evidence that shows the importance of pre-service teachers reflecting on personal epistemologies and the nature of critical thinking, there is no clear consensus for how this should occur. However, recent research focusing on interventions may highlight how effective reflections on personal epistemologies can be achieved.

One teaching intervention focused on critical thinking with pre-service teachers. Valianides and Angeli (2005) investigated how two types of interventions, the *Infusion* intervention (where pre-service teachers discussed an article, prepared outline for a paper on the issue, and reflected on their thinking, listened to a short lecture, and a conversation with the researcher) and the *General* intervention program (pre-service teachers listened to lectures and had a discussion of an article for preparation for a paper) were implemented. It was found that pre-service teachers involved in the *Infusion* intervention experienced more change in personal epistemologies than those involved in the *General* intervention.

Another way to promote explicit reflection on personal epistemologies involves the use of calibration. In order for teachers to reconstruct their existing personal epistemologies, it may be important for them to calibrate "their knowledge of varying conceptual approaches to a domain" (Cunningham et al., 2004, in Maggioni & Parkinson, 2008, p. 454). It is suggested that well-

calibrated teachers can clearly identify the extent of their existing beliefs and therefore work to obtain knowledge/beliefs in areas where they lack understanding (Cunningham et al., 2004). As Maggioni and Parkinson (2008) note, "addressing teachers' beliefs without improving their calibration would not be very effective" (p. 454). Therefore, it is necessary to build understanding of effective calibration training for pre-service teachers to promote more effective explicit reflections on personal epistemologies.

While calibration training may assist teacher educators to increase awareness of general beliefs/knowledge and the extent to which their teaching practice reflect these understandings, personal epistemologies may in turn influence the extent to which teachers are able to engage in calibration (Maggioni & Parkinson, 2008). It is argued by Stahl et al., (2006) that teachers with sophisticated personal epistemologies are more adept at calibrating "their goal setting and planning to the difficulty of the task" (cited in Maggioni & Parkinson, 2008, p. 455). In order for teachers to calibrate their personal epistemologies to those specific to a teaching paradigm, teachers need to be explicitly aware of the beliefs involved (Muis, 2007 cited in Maggioni & Parkinson, 2008,). This requires engagement in explicit reflection on personal epistemologies in order for teacher educators to understand their personal epistemologies, to calibrate these to a variety of teaching situations, and thus reconstruct their personal epistemologies.

The current research has shown changes have taken place in beliefs about knowing and learning over the first two years of a teacher education course. It would be interesting to determine what factors may have promoted such changes. While time and maturation may certainly play a role in the development of these pre-service teachers' personal epistemologies, it could be speculated that the nature of a teacher education program, with a specific emphasis on reflective practice, may also effect significant changes. It is expected that the Time 3 data collection scheduled to take place in late 2010 will shed some light on pre-service teachers' perceptions of why changes have taken place and enable a critical reflection of the ways in which our pre-service teacher education programs may or may not facilitate such changes to more sophisticated ways of knowing.

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