# Ascribing Legitimacy: Pre-service Teachers Construction of Science Teaching Expertise in Multiple Communities

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## Abstract

This paper is a case study describing contextual influences on elementary pre-service science teachers' views of expertise and community membership as they came into the fold of public schools. It documents through the framework of Lave and Wenger's Situated Cognition Theory how the joint enterprises, shared repertoires, and mutual engagement in the learning of science and math teaching were affected by the novice teachers' views of expertise and mastery. Specifically it describes how efforts to promote inquiry-based practices through participation in a Community of Practice with expert elementary teachers were diminished by pre-service teachers' experiences in other classrooms where science instruction was not a focus. Implications are discussed for making changes in novice teachers' beliefs and practices through improved programs, mentoring, and collaborative partnerships.

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## Introduction

*Scientific and Mathematical Literacy in Pre-service Teacher Preparation*

That providing students with opportunities to construct knowledge using explicit, tacit, cognitive, social and authentic evidence, especially in collaborative circumstances creates meaningful instruction is emphasized in reform documents (NRC, 1996). Such instruction immerses students in the learning process; allowing them to become active members in the scientific community. How students interpret and process knowledge construction is an integral part of the educational and psychological underpinnings of current reform-based recommendations. From these perspectives we aim to help pre-service elementary science teachers appreciate the tenets of inquiry learning (vonGlasersfeld, 1989; Driver, Asoko, Leach, Mortimer, & Scott, 1994) and the importance of collaborative contexts (Ball, 1988; Roth, 1995, 1996, & 1997; Richmond & Striley, 1995; Eichinger, Anderson, Palincsar, & David, 1991). Appreciation of inquiry based learning and its application in the classroom are essential for pre-service

elementary science teachers. This case study explores tensions inherent in helping pre-service teachers develop an inquiry approach to science teaching. Tensions that came not only from their beliefs surrounding learning and teaching formulated prior to and during their enrollment in university teacher education courses (Brickhouse & Bodner, 1992; Duschl & Wright, 1989, Hodson 1993; Lantz & Kass, 1987; Lederman, 1992, 1999; Lortie, 1975) but also from their participation in several different communities of practice (Wenger, 1998).

Professors in science education with inquiry based philosophies and constructivist backgrounds use these premises when creating learning environments for pre-service elementary science teachers. Specifically these expert professors use three important components shared by the perspectives of the National Science Education Standards (NSES) 1) recognize norms of classroom discourse which run contrary to constructivist notions, 2) engage pre-service science teachers in authentic problem settings and engage them in reflecting upon their actions as teachers (Schon, 1983), and 3) interpret reform recommendations (AAAS, 1989; NRC, 1996) to guide future teacher learning, evaluation and research.

Few studies in science teacher education document how complex and arduous it is to create substantive change in pre-service elementary science teachers' beliefs and practices or to impart constructivist philosophies in less than congruent settings. While we are supportive of inquiry and believe that teachers should teach this way, we are skeptical of reports that large numbers of teachers are entering the workforce prepared to teach according to the NSES.

*Challenging Pre-service Teachers Beliefs and Experiences*

The approaches advocated in the NSES contrast with the landscape of observed practices pre-service teachers are exposed to during their preparation (Carlsen, 1991 & 1993; Cazden, 1988; McDiarmid & Kelly, 1997; Feinman-Nemser, McDiarmid, Melnick, & Parker, 1989). Pre-service science teachers perceive traditional approaches such as disseminating factual information, concentrating their teaching efforts on skill or algorithmic practice, and retrieval of information as "normal" for two reasons. First, these practices are commonplace in many public education field experiences. This fieldwork is often the first time pre-service teachers formally observe authentic classroom behavior. Secondly, and perhaps more importantly, these traditional experiences are aligned with their own prior science education (Florio-Ruane & Walsh, 1980; Borko, 1991; Rodriguez, 1998).

For many pre-service elementary science teacher candidates, engaging in inquiry lessons is foreign and uncomfortable. It not only requires understanding of the content in deep and complex ways but it also requires challenging their learners to think and act in new ways in the classroom (Gee & Gabel, 1996; Lampert, 1990). Gee (1989) argues that learning a new discourse of this kind is analogous to putting on an entirely new costume complete with instructions for how to respond differently in specific social settings. Because the creation of a new science discourse community implies the reconfiguring of

participation, rewards, and authority; many accepted norms are no longer functional (e.g. grades, correct answers).  Consequently, novice teachers must not only learn to function within the expectations of a discourse community they must also "unlearn" much of what they have already come to expect as ordinary (Ball, 1988).

One of the first steps toward assisting pre-service elementary science teachers in teaching for reform standards is to challenge their' pre-existing beliefs about the adequacy of their knowledge base for teaching science; including both overconfidence and  insecurity (Abell, Bryan, Anderson, 1998; Appleton, 1992; Ball, 1988; Jeans & Farnsworth, 1992; McDiarmid, 1990). Those who have been successful science learners often underestimate their preparedness to teach the subject, especially in a manner that contrasts with their traditional learning experiences.  At the other end of the spectrum, many pre-service elementary teachers shy away from trying any new experiences because of their self-perceived weak science background. Their current scientific abilities are gauged upon past, failed, traditional experiences (Appleton, 1992, Jeans & Farnsworth, 1992).

Unfortunately, research has shown that simply challenging pre-service elementary science teachers' beliefs is insufficient for making dramatic change (Adams & Krockover, 1999; Cook-Freeman & Smith, 1997; Author, 1999).  Not surprisingly, these findings echo prior psychological studies arguing that accommodation of contrasting beliefs requires the believer to develop dissatisfaction with previously held conceptions, understanding and appreciation of a contrasting conception, practice using the new conception, and application of the new concept in a future  endeavor (Posner, Strike, Hewson, & Gerzog, 1986). In other words, pre-service elementary science teachers will need opportunities to test out new teaching practices in order to begin to have faith in them. We investigated the degree to which this was possible in a multi-faceted elementary teacher education program.

*Communities of Practice Impacting Teacher Education*

The inability for teacher education institutions to regularly produce excellent elementary science teachers can be explained in part by considering the multiple communities influencing teacher education programs.  Beyond geographical and logistical differences, there is an implicit boundary that exists between university faculty and public school practitioners. University faculty are often the advisors for pre-service teachers and are largely dependent upon public schools to offer relevant teaching experience. University professors consistently strive to gain legitimacy and collaboration with public school practitioners to establish mutual goals for pre-service elementary science teachers.  If university faculty are unsuccessful in real collaboration, there is little support for challenging overly simplistic or misdirected views of teaching science.  Ad hoc solutions and teaching advice, overt directives, and pragmatic solutions offered by public school practitioners to complex educational issues will resonate with our novice teachers.   As Lave and Wenger (1991) argue, "directive teaching in the form of prescriptions about proper practice generates one circumscribed form of participation [in

school]…the goal of complying with the requirements specified by teaching engenders a practice different from that intended" (p. 96-97).

Pre-service teachers often operate amidst competing ideologies as teachers often suggest views about teaching that compete with those offered by university faculty. Whether on an individual basis or some collective socio-political agreement to oppose constructivist approaches, resistance has been shown to restrict the effectiveness of teacher education initiatives towards reform. This is partly why some argue (Ball, 1988; McDiarmid, 1990) teacher novices must also be able to observe experienced teachers modeling different strategies that map well onto constructivist notions of teaching. Granting pre-service teachers time and incentives to prepare lessons, receiving feedback from individuals they perceive as experts, and protecting them from the accountability pressures that potentially restrict their choices are all aspects of constructing a meaningful context geared toward changing teachers' practices.

Conflicting ideology arises in the form of well-organized resistance to reform recommendations from the school (Claus, 1999). It may also come in the form of pre-service teachers negotiating terms of engagement in their university experience (Adams & Krockover, 1999). University students themselves operate within an accepted set of beliefs and values harboring separate agendas. Some of these agendas are reminiscent of public school students (e.g., negotiation of minimum standards) which have been well documented (Jackson, 1986; Goodlad, 1984; Cusick, 1983; Lemke, 1990) but have not been well studied in university settings. This kind of resistance to constructivist teaching among pre-service teachers can be more tacit. For example pre-service teachers may profess student-centered beliefs but behave in teacher-centered ways. While pre-service teachers may think they have changed their beliefs, researchers argue that they can still operate in contrast to professed beliefs without deviating from the ways that they were socialized to perform in classroom contexts (Simmons, Emory, Carter, Coker, Finnegan, Crockett, et al., 1999).

Given the teacher education program's limitations, contact hours and the uncertain context in which they are placed, pre-service science teachers may also focus upon minimalist strategies of surviving the credential experience. Regardless of its origin or manifestation, resistance to inquiry teaching stemming from pre-existing negative student attitudes is larger than the literature on teaching reform initiatives indicates (Cook-Freeman & Smith, 1997). Teacher educators must routinely balance the interests of multiple communities while promoting new kinds of lenses to old school problems. Their arduous task is to offer pre-service teachers the opportunity to strengthen their learning and provide support for changing and expanding teachers' knowledge both in the content area as well as that of the pedagogical choices associated with inquiry teaching.

Framing our work within the context of communities of practice (Wenger, 1999) was central in the orchestration of our methods course as well as the analysis of teacher learning we examined. We assumed that pre-service teachers must themselves engage in scientific inquiry as learners before they could fully embrace reform recommendations. According to Lave and Wenger (1991) learning to teach (like other apprenticeship

ventures) is influenced by factors other than the dissemination of expert knowledge or skills.  Rather than defining it as the acquisition of propositional knowledge, Lave and Wenger (1991), situate learning

> "in certain forms of social co-participation. Rather than asking what kinds of cognitive processes and conceptual structures are involved…[they inquire] what kinds of social engagements provide the proper context for learning to take place" (Lave and Wenger, 1991, p. 14).

Situated learning draws attention to participants' engagement in and interpretation of social environments.  Co-construction and co-participation in learning endeavors as members of a community transcends the considerations of individual shifts in knowledge. Learning to be an expert contributor in this community and how to speak about the relations between newcomers and old-timers is described by Lave and Wenger (1991) as the processes of legitimate peripheral participation (LPP). Learners enter the process of becoming a full participant in a social community by developing identities, engaging with artifacts and apprenticing with experts. *Identity*, in particular*,* is a central construct of LPP as Lave and Wenger (1991) argue that, "learning and a sense of identity are inseparable:  they are aspects of the same phenomenon." (p. 115). Identities are carved out individually and collectively in relation to members' sense of shared repertoire and established means of mutual engagement (Wenger, 1999).  Further, communities are productive to the degree that they operate toward an agreed joint enterprise which shapes the collective identity of the community.  The Communities of Practice perspective offers a framework for considering the multidimensional social worlds which pre-service teachers negotiate.  Each of these communities has a distinct form of engagement, joint enterprise and repertoire (Wenger, 1998). In teacher education endeavors, individuals can clearly develop idiosyncratic ways of managing in cohort situations in which a group of students progresses through a credential program together, the cohort can evolve  its own community of practice where resources are distributed, knowledge is shared by the group rather than being the purview of individuals, and each member contributes expertise of some aspect of practice.

Each community has its own norms of behavior and ways of negotiating with the institutions in which they reside. These are not always aligned and pre-service teachers have to manage these various norms in personally meaningful ways. The more aligned the communities are, the less stressful the management effort will be.  Situated learning perspectives highlight the importance of attending to communities of practice in order to understand issues of transfer. Cobb and Bowers (1999) noted that students need to view practices in different contexts as commensurable in order for the transfer of skills and ways of thinking to transfer from one context to the other to occur.

We used the framework of Communities of Practice to better understand why our efforts to cultivate inquiry orientations in our pre-service elementary science teachers often fail. We studied the effectiveness of our efforts as we examined our students' reflections and practices (Schon, 1983).  To report on our progress in cultivating tenets of

inquiry learning and teaching among our pre-service elementary science teachers, we address the following questions.

1.  How do pre-service elementary science teachers interpret their immersion into a community of practice in which constructivist science pedagogies are promoted?

2.  What factors of their pre-service experience affect their appropriation of new teaching approaches into their own repertoires?

Method

*Instructional Context*

The situated learning perspective shaped our work in two ways. First, it directed our attention to the various communities to which the pre-service elementary science teachers belonged, particularly the norms of behavior in those communities, the pre-service teachers' level of participation along the apprentice/expert continuum, and the goals and purposes of each community. Second, the situated learning perspective reminded us to attend to ourselves as members of various communities. In this case, we were both new faculty members at a large institution with ten different elementary certification programs. We acknowledged that each had a specific and unique community that we would have to negotiate.

The first author taught elementary science methods in two of the seven different field based cohorts in the College of Education. For one of those cohorts he identified a group of local elementary teachers from the community who taught elementary science classes using constructivist methods to collaborate with his elementary pre-service teachers. The pre-service teachers worked with these local teachers during specific assignments in the science methods course. He felt that engaging pre-service teachers in observing, planning, teaching, and reflecting with the collaborating teachers would promote selected values and practices and would provide the pre-service teachers with an apprenticeship experience.  Consequently, our study became a case study defined by the experiences of a single cohort among several made available to pre-service teachers at our university.  Lave and Wenger's model for interpreting the experiences of emerging knowledge and cognition is particularly apt for describing this context as,

> Apprentices gradually assembl[ing] a general idea of what constitutes the practice of the community.  This uneven sketch of the enterprise (available if there is legitimate access) might include who is involved; what they do; what everyday life is like; how masters talk, walk and work, and generally conduct their lives; how people who are not part of the community of practice interact with it; what other learners are doing; and what learners need to learn to become full practitioners. (Lave and Wenger, 1991, p. 95)

We hoped that the learning done at the University would transfer to teaching in the public school through this apprenticeship experience. In this particular program the

pre-service elementary science teachers also had a concurrent placement for other university course assignments at various schools in the same single district.

TRIBE School was the pseudonym for the chosen site for this experience because the teachers there had expressed interest in inquiry science and had established classroom communities where children were used to engaging in the open-ended activities associated with inquiry based science instruction. Much of the work of creating a community of practice had been done by the classroom teachers because they had developed a common view of science teaching supported by various activities with the first author. The first author assumed it would be easier for the pre-service teachers to complete inquiry science with children at TRIBE School because the children were used to engaging in inquiry. He assumed the pre-service teachers' concurrent placement would create obstacles because the existing communities of practice at the other schools in the district were typically oriented toward traditional instruction and not constructivist science teaching practices. 12 of the PSTs were located at TRIBE for their concurrent placement. The rest were at various other schools.

The content of the methods course included pre-service teachers' reflecting upon their own experience as learners as well as different notions of what it means to teach from vicarious engagement in detailed classroom cases (See Appendix).  In several assignments students were asked to observe and interview children engaging in inquiry activities without direct teacher instruction.  Pre-service teachers were asked to read from a variety of genres supporting reform positions in science education. Most importantly all pre-service teachers were required to teach three inquiry based lessons at TRIBE school and to write about these experiences. This multi-faceted approach to teaching methods was meant to reach students from a practical, experiential, and theoretical perspective—encouraging them to reflect upon what kind of beliefs they held, understanding what actions are key indicators of their beliefs, and reflecting upon the complexity of crafting teaching for oneself.

*Key Participants*

Not far into the data collection process we learned that we, as new faculty members in the College of Education, were newcomers in a context where the communities of academics, practitioners, and novices (university students) were already well defined.  It wasn't necessarily the case that we were inexperienced since between us we had already more than 10 years' experience teaching elementary methods courses at other universities.  Rather, the culture of our new university had developed its own unique culture esoteric to the outside observer.  We did not have the luxury of limited peripheral participation as we entered these new communities. We were expected to take up full participation immediately. We felt that a focus on the similarities and differences between these contexts would allow us to participate more effectively. Next, we solicited the aid of an exemplary pre-service teacher in a role similar to that of Tobias' student researcher (Tobias, 1990).  It was imperative that this student was revered by peers and could bridge the gap between us and the pre-service teacher community. Her role in the research team was as documenter, informer, and ethnographer after the conclusion of the

methods course.  Once the student was invited into the study we did not attempt to conceal her identity as a researcher.  The results reported in this study were heavily influenced by a representative student "voice" as a result of her direct involvement in data collection and data analysis.  Our study hence became an effort to better understand our students and the communities to which they belonged as well as an effort to situate ourselves to the new contexts in which we would be working.

The selection of this student researcher was influenced by her demonstrated knowledge and alignment with promoted teaching ideologies associated with current science reform.  She was also a respected student leader and was nominated by her peers to an internal steering committee to assist the professor in interpreting student concerns.

*Data Collection and Analysis*

This section describes the sources and methods used for collection and analysis of data as well as provides a rationale for the kinds of questions which guided our investigation.  Primary data sources included notes from class meetings, student journals, researcher journals, field notes, and follow-up interviews, and student focus groups.  This rich variety of data sources was necessary because we sought to develop a defensible argument that described pre-service elementary science teachers' views of teaching "expertise" in this situated cognition context from artifacts of planning, teaching and reflecting (Baum-Brunner, 1993; Evertson & Green, 1986).

Focus groups were conducted on a biweekly basis to bridge the two communities. Not only did this focus group clearly identify leaders of the group right away, the group also recognized pre-service teachers who would struggle in the course and those who would likely succeed.  Once chosen this panel met biweekly with the instructors to discuss the goals and assignments of the course.

A list of general, open-ended, explicit and implicit questions regarding students' participation in planning and teaching guided our initial inquiry. To develop a deeper understanding of students' professed beliefs, students were observed in their classroom setting and asked to explain the differences in their plans for using inquiry and their perceptions of success. In short, we were interested in understanding what sense the group members were making of the activities and what prior knowledge influenced their thinking. To encourage reflection on their experiences and to provide us with critical insight into how students were making sense of their learning, students were asked to maintain a weekly journal which served as a log and record of their learning. In summary, the research catalog consisted of the copies of student journal, field notes from the instructor entries, our own research notes and comments, transcripts from group and individual interviews, and references to the supporting materials artifacts (e.g. email communication).

Our data analysis methods were an amalgam of participant observation, ethnographic interpretations, and  deconstructing teaching issues, because we did not trust the self-reported beliefs of interviews with pre-service teachers, nor our own

emotionally laden observations driving our inquiry of the context (Cochran-Smith & Lytle, 1990; Clark & Peterson, 1986). These methods allowed us to triangulate and member check observations and artifacts.  Data sources were gathered and organized into research catalogs. Student journals and field notes were chronologically correlated to each entry and event. These correlations served not only as sequential markers but as important sources for comparative analysis of field-based and university experiences. Events, transcriptions, and artifacts were coded with the input of the participant/researcher/student to guide the analysis and subsequent history written about these artifacts.   Codes were subsequently re-examined for their verifiability and prioritized according to their ability to describe a wide array of events where conflicts or congruence were found.

Results

*Explicating the Community of Practice Shared by University Pre-Service Teachers*

> "My big problem is that I really don't know enough about the subject to create a decent lesson."
> (Tony's Journal September, 1999)

Pre-service elementary science teachers in this study maintained a tightly knit cohort group throughout the course of this study. The science methods course was offered in the second semester of an intense two-semester credential program. Strong relationships and roles were formed within the group which encouraged pre-service teachers to reinforce beliefs about learning and teaching, commiserate around perceived obstacles and negotiate the expectations of the program. This group constituted what might be best termed a "quasi-community". Following Lave and Wenger's (1991) model it could not be considered a community of practice due to a lack of intergenerational relationships. There were no experts handing down practices over time.

The pre-service elementary science teachers shared many conservative beliefs concerning expert teaching and, since they had only brief contact with public schools in their new roles as pre-service teachers, these beliefs were heavily influenced by their science experiences as learners.   The pre-service teachers' community of practice represented their participation as members in public schools for most of their lives, understanding their membership through an apprenticeship of observation (Lortie, 1975) and socialization.

*Joint Enterprise.* The university pre-service elementary science teacher cohort group had three competing enterprises or goals, some of which were imposed by the university and others that were taken on as a matter of self-preservation. These included 1) completion of course assignments, 2) interpretation and application of theoretical constructs presented in the course, and 3) the maintenance of one's identity and experience as a teacher.

The first enterprise, completing the requirements of the course and program was the most pragmatic and potentially the most costly if it was not attended to. One of the most frequently mentioned concerns for students was their lack of time to complete required assignments.  Students regularly and openly discussed strategies to reduce commuting time, complete assignments, and please their assigned master teachers. One precipitant of this enterprise was consistent complaints among many pre-service teachers as they recorded in journals feeling "overloaded" and wary of "long reading assignments" of more than 5 pages.

First day impressions - OVERLOAD!  The course objectives and work-load look daunting.  I hope the reading assignments are not too long or technical, it looks like a lot of reading…we have varying schedules, for work, teaching, and families.

The second enterprise of the community was imposed by the university course instructors--to engage with the ideas presented by the University faculty. Students were expected to read and think about inquiry science, consider the complexity and advantages of teaching in this way. The requirements of the class asked that inquiry based science methods be incorporated in journal entries, interviewing children, writing and revising lesson plans and teaching inquiry science lessons. It was explicitly stated in the syllabus that failure to at least address this enterprise would also risk failure in the course and subsequent delays in receiving accreditation.

The third enterprise of the community was to establish and maintain the members' identities as knowledgeable people who had already developed a solid understanding of teaching through their experiences as students in school. This enterprise involved boundary maintenance (Wenger, 1998); separating practical experience from the theoretical world of the university.  It also represented one of the central tensions of the course—to honor students' beliefs about teaching while engaging in activities and discussions that attempted to change those beliefs that did not align with constructivist theory.  This tension is described as a "conflict between continuity and displacement" (Lave and Wenger, 1991, p. 114) as newcomers were required to engage in practice and understand it though it was still foreign to their experience in other communities. Students' personal goals, ranging from egocentric quests to gathering knowledge, tools and practical resources showed how disjunctive and individualized the cohort was on this enterprise.

Matt: I feel I pretty much know what I need.  I would like to learn practical things more than anything else. There is a difference between what should be taught and what, in most cases, is realistic in the modern classroom. …I am hoping we get some practical examples and advice.  I will be going on the internet in hopes of finding a suitable lesson I can adapt.

*Shared Repertoire.* The repertoire of the group in relation to science methods grew out of their shared histories (primarily based on previous failures or fears) as science students. While none of the students went to elementary school together, their

memories of science were very similar as were their feelings about these memories.   This collective history is similar to that found in other studies (Bryan & Abell, 1999; Abell & Bryan, 1997).   Students reported their discomfort with their own scientific knowledge and anxiety about teaching students in a content area they felt inadequately equipped to teach.  Journal entries exposed this group's need for increased "content area knowledge" and their fears of "not knowing enough to create a decent lesson plan".

Erin: What I want from Science Methods class is to be comfortable [teaching science]. Science had always been a hard subject for me and I have difficulty in learning it. It is important for an instructor to provide lessons that are engaging, interesting, and challenging.

Janice: I have never been good at science.  Science for me was always, "Open your book to this page, copy these definitions, and answer the questions at the end of the chapter.

Kent:   I need this class to help me gain CONTENT AREA KNOWLEDGE.  Science is one of my weaknesses primarily because I have never learned to enjoy science and therefore have retained very little information. [emphasis his]

Students would routinely describe histories of difficulty in science, referring mainly to negative experiences in science in high school.  Only two students reported having a positive experience in science at any level, and most students were unable to recall even one positive science learning experience. It is important to note that part of this discomfort and perceived lack of preparedness may be attributed to the imbalance of attention to reading and literacy in their teacher education program.  In part this had to do with major literacy movements happening locally in this urban setting and part by the accountability movement inspired by No Child Left Behind.

*Mutual Engagement.* Some university courses never evolve into a community of practice. Although class members may have the joint enterprises and shared history described above, members never engage mutually in their enterprise or recognize the similarities in their own learning experiences. Wenger (1998) includes community maintenance, relationships, and shared ways of doing things as aspects of mutual engagement.

Students' understanding of their mutual engagement in the community was evident early on and far exceeded the first author's understanding.  Roles for students in the community appeared pre-determined and self-selected.  When the instructor first announced there would be substantial collaboration and group work required for unit plan development, students unanimously rejected the possibility of the instructor selecting the groups.  Within a matter of minutes all students had divided themselves into triads for unit planning and collaboration. Though the students were asked directly why they chose to work with one another, they were generally inarticulate and responded with "We've just always worked together in the program… We've got group projects going on in all our classes and we have to keep a lot straight."

Upon further analysis we found a striking pattern for the roles students reportedly took on within their groups while completing assignments. 4 of the 5 triads verified in debriefing that 3 roles were used that mimicked the joint enterprises model above. The focus of these 3 roles were: 1) the big ideas represented in the course (Joint enterprise #1), 2) the tasks and timelines for completing assignments (Joint enterprise #2), and 3) the obstacles to teaching for understanding (Joint enterprise #3) (See figure 1). Members described that there was a specific individual who would connect the group tasks with the larger set of ideas represented by the readings, feedback from instructor, and goals of the program. Similarly, there was an individual in each group who did the bulk of the complaining and raised issues and obstacles during group work. Finally, there was a third and separate individual identified in each group as the taskmaster who always found a way to move the group forward in the assignment.
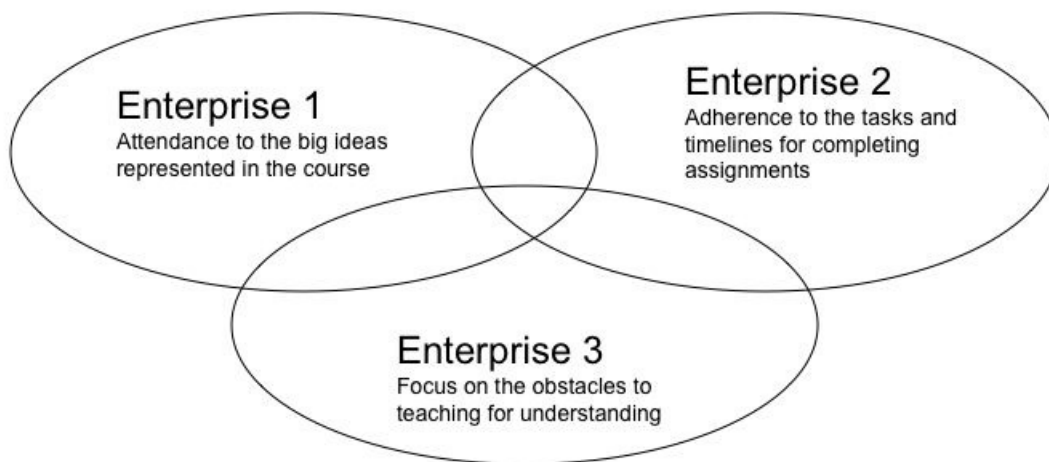


**Enterprise 1**
Attendance to the big ideas represented in the course

**Enterprise 2**
Adherence to the tasks and timelines for completing assignments

**Enterprise 3**
Focus on the obstacles to teaching for understanding

Figure 1: The emergent joint enterprises of small group work within the class

*Explicating the Intended Community of Practicing Science Teachers*

*Joint Enterprise.* The TRIBE Elementary teaching staff maintained at least three pertinent joint enterprises in their collaborations with the university, including: 1) attending to the learning of their students, 2) maintaining independence from district imposed literacy reform, and 3) socializing pre-service teachers into regular classroom practices which accentuated their pre-established learning contexts and routines. The

first enterprise was one of the reasons the university worked so closely with TRIBE Elementary. Both faculty and administration had a shared vision and a good relationship that linked their joint commitments to student learning.  It was a school that scored among the highest level of their district literacy measurements despite their independent strategies for SES grouping with other schools in their immediate vicinity.  Other schools had succumbed to the pressures of the large urban district to operate a pull-out model that TRIBE faculty deemed inequitable.  However, because of their high scores, teachers were allowed to teach in ways they believed were ethical amidst growing pressures to conform.

The university had a strong literacy and reading faculty and their relationship with TRIBE was symbiotic in that the university needed to place teachers and TRIBE continued to recruit pre-service teachers for their expertise.  One teacher commented, "We love to have students [from this university].   We get approached all the time from [other] institutions.  They just don't invest the time and contact with teachers to prepare them for REAL teaching."   Clearly TRIBE teachers appreciated the institution's commitment to strong science teaching.  Though pre-service elementary science teachers also saw these differences they were often interpreted differently as burdensome or onerous. However, to be a good teacher and part of the accepted staff at TRIBE, pre-service teachers needed to demonstrate a clear interest in children's learning and a willingness to go along with established routines.  Like the pre-service teacher cohort, the joint enterprise involved boundary maintenance (Wenger, 1998) separating the insiders from others through shared or espoused beliefs about teaching while engaging in activities and discussions attempting to change them.

*Shared Repertoire.* The shared repertoire of the TRIBE teachers included both professional and personal commitments.  Not only were teaching events and artifacts like morning announcements, class schedules for literacy development and science time practiced routinely, other more reflective professional teaching repertoires were also practiced and expected of one another.  These included time after school to coordinate instruction and share resources, planned development time for extending instruction, reporting back on projects and committees, and also for formulating a literacy vision and plan of instruction to counter district decisions.  As the principal described,"[to ignore the district pullout model] that they will leave us alone if our scores stay up, but I've been told that they will pull funding if we don't comply."

Teachers also maintained a shared repertoire of a more personal sort as well.  There were baby showers, birthday lunches, and other social repertoires that distinguished them from the cohort of pre-service teachers.  Even though some pre-service teachers were placed at TRIBE for up to a year, there was not a report of any pre-service teacher receiving recognition on a birthday lunch or other special event.  There were even regular dinners on specific weekends at which wine and music were enjoyed but it was in the words of one teacher, "for the old seasoned ones" to get together. While this community had a shared repertoire, it was not inclusive of the pre-service teachers.

*Mutual Engagement.* While some faculty never evolve into a close community of practice, this could not be said of TRIBE. Teachers shared the joint enterprises, history,

repertoires, vision, and the understanding of one another's classrooms to be mutually engaged in moving in the same direction as a faculty. Wenger (1998) specifies avenues of community maintenance, relationships, and shared ways of doing things as aspects of mutual engagement.  The mutual engagement at TRIBE had only been strengthened by recent bouts with the district administration.  With threats that funding would be pulled for non-compliance with a district mandate, teachers petitioned the principal who fully backed his teachers to have a parent night explaining the dilemma and the teachers' solution to the problem.  Every teacher was in attendance that evening along with more than 200 parents in a filled multi-purpose room to hear how the teachers were meeting the needs of the children and ask the parents to begin fundraising in preparation for the nearly $40,000 that could be lost with a district power play. The first author attended the town hall meeting, observing the support from parents, commitment of teachers to one another and the course they were taking, and unanimity shared among community members, teachers and principal.   As one teacher said,

> We're all in this together.  We know we're doing a good job, the parents know, and the scores show it as well.  Look at them.  No one is complaining, they're all agreeing with us.  They're asking what they can do to help.  We have our ducks in a row and we're doing great…I don't know why the district would insist on something that doesn't make any sense to any of us.

While each teacher had a different kind of role in the parent night; some were speakers, some handed out fliers, some collected signatures on a petition; they were all mutually engaged in the joint enterprise involving a professional commitment to one another and the children they taught every day. It was within this community of practice that we sought to assist pre-service elementary science teachers in legitimate peripheral participation, aiming to model reflective practice and planning toward specific learning outcomes through collaboration.  It was within this community that the first author taught example lessons in classrooms with children and assisted teachers in the development of their own lessons while the pre-service teachers observed, and as pre-service teachers observed, facilitated interviews between pre-service teachers and children, and supported pre-service teachers to plan lessons of their own for eventual use.

*Explicating the Successful Transfer into the New Community of Practice*

As discussed earlier, TRIBE Elementary School was an exceptional community of practice that contrasted with traditional descriptions of elementary science teaching. The school boasted exceptional leadership in the areas of teacher professional development, parental involvement, student equity issues, and a strong history of university collaboration.  Several teachers had chosen to focus upon students' conceptual learning and the promotion of inquiry teaching strategies.

Some pre-service teachers in our study were able to transfer their knowledge and transform their practice in the methods course, describing their own experience as not only successful but transformative. These were students who internalized the premise of their methods course, excelled in all assignments, synthesized readings and applied theoretical frameworks to their own experience teaching.  When we inquired about their

growth as a teacher, pre-service elementary science teachers described attributes and insights they had acquired beyond simply learning techniques, skills or strategies to present science better to students.

Solumai, like several other pre-service teachers modeled a critical perspective regarding her experiences as a student and teacher. However, there was a limit to the number of pre-service teachers TRIBE Elementary could support. Of the more than two dozen pre-service teachers in the cohort, less than one fourth were placed for the year at TRIBE. Her immersion in this community of practice was more intense than pre-service teachers who spent their mornings at another school placement prior to the afternoon methods course at TRIBE. Solumai described the difference she observed between pre-service teachers early on in the methods course. "Most students wanted one question answered in this course, and one question only, "How do I teach science?"… I [quickly] realized that the course [dealt with]…a great deal of information and reflection beyond science methods instruction." Lave and Wenger (1991) argued that the perception of who holds "expertise" will shape an individual's participation and practice. It was clear from many of the pre-service teachers who experienced minimal transfer that they were placing their notion of expertise in mentors outside TRIBE, in more traditional and didactic settings.

The pre-service teachers who were successful in their transfer into this new community of practice recognized the complexity of teaching and the demands of teaching science for deeper understanding among children. Their journals reflected a strong commitment to examining children's thinking, not only after their assigned interviews and teaching but throughout the course. Moreover, successful pre-service science teachers were prone to recognize the limitations of their own attempts to address the pre-conceptions and problem solving strategies of children. Following their attempts to teach the units they developed, successful pre-service science teachers used course readings to reconstruct their struggles and reformulate their plans for teaching.

Solumai: I feel that I tried to be very open-minded about the course, and although I embraced the methodology, my implementation was poor. But of course, that's where the reflective teaching part comes in.

Despite such successes with some pre-service teachers, we endeavored to explore the kinds of interpretations our less successful students constructed of their methods course experience and the reasons for their minimal transfer. Our purpose was to explicate several aspects of the arduous task of making change, particularly in our formative years at a new university. In the remaining sections of our results we will use pre-service teachers' journals, teaching observations, completed assignments, and follow up interviews to outline the challenges we faced with pre-service elementary science teachers whose experience was less than transformative, regardless of the positive collaboration and constructivist approach to elementary science instruction advocated by both the University and TRIBE Elementary.

*Challenges of Transference for Newcomers*

   *Challenge #1: Redefining expertise in science teaching requires shifts in pre-service teachers' identities.*   The first challenge in methods course instructors was making closely held beliefs about science teaching and learning more explicit for our pre-service teachers (Ball, 1988, McDiarmid, 1990). Pre-service teachers' socialization as learners in a conservative public school community of practice significantly shaped their notions about what constituted "good teaching".   The pre-service teachers' perceived joint enterprise contrasted with that of the TRIBE school/university methods course collaboration and were manifest in many ways including the pre-service teachers' self-assessment, critique of TRIBE teachers, and interpretations of the class readings. Throughout the course the majority of students maintained a deficit model for learning science which carried over into their teaching.

Nancy: As a young girl I hated science and always had a deathly fear of snakes. I would dream of falling into a pit with snakes biting me and I couldn't escape.  I never saw snakes as a girl… and it wasn't until I recently found my $2^{nd}$ grade reading basal that I realized that my dreams were based upon a picture I had seen in my [$2^{nd}$ grade basal] book.  If someone would have told me that the picture of the coral snake's nest in the book was not local to my area or at least said something besides, "Read this and answer the questions," maybe I wouldn't be so scared of snakes [or teaching science] today.  (Nancy's Journal, October, 1999)

   With the understanding that many pre-service teachers' experiences were void of any positive engagement in science, the first author routinely engaged students in science inquiry lessons.  After each lesson, the pre-service teachers were asked to reflect upon their learning.  Many recognized that the lessons were dramatically different from the science they had experienced as children and in their non-TRIBE placements. Pre-service teachers wrote journal entries describing the lessons and reflecting upon how they wanted and planned to teach science. In addition, the readings pre-service teachers were given also helped them to understand the new community of practice from a more theoretical perspective.

   After observing teaching and reflecting upon articles and anecdotes of teachers trying to enact constructivist teaching methods, pre-service teachers were asked to discuss their interpretations of teachers' efforts.  Several pre-service teachers appeared to make connections between what they were being asked to do in methods class with some of the teaching case evidence they were presented with. Both Sally and Tony expressed interest and excitement when they saw examples of the constructivist model they were reading about. Tony emphasized "Finally, we have a usable reading! A concrete way to apply the constructivist model of teaching…"  Learning to participate as a member of a new community is seldom as straightforward as watching and then performing.  While pre-service teachers noted differences in teachers' roles and depth of childrens understanding, many pre-service teachers did not abandon their views of teacher expertise.  As Lave and Wenger (1991) argued, learning is never simply a matter of the

'transmission' of knowledge or the 'acquisition' of skill…knowers come in a range of types…[and are never unproblematic]" ( p. 116).

The majority of pre-service teachers were highly critical of teachers' efforts to let children discuss their own solutions to problems. In support of research conducted by Bryan and Abell (1999) pre-service teaches were unable to objectively observe teachers attempting to try inquiry teaching without offering many critical comments and suggestions. Despite their diverse readings, videos, example lessons, live observations, and even engagement in science lessons modeling the constructivist approach, pre-service teachers mutually engaged in the practice of criticizing teachers' efforts and explaining why the teaching they observed was inappropriate or misguided.  The joint enterprise pre-service teachers were engaging in was the maintenance of their own identity as learners and perceptions of themselves as teachers.  Because of their uncomfortable experiences in science and their frustration with not having sufficient guidance, students found fault with teachers letting students debate incorrect answers.  As Erin surmised regarding an example of teaching children that sweaters do not produce heat (Watson & Konicek, 1990),

Erin: I think Deb O'Brien [In Watson & Konicek's article] waited entirely too long to give students the answer.   Why didn't she just tell them? Doesn't she know that these kids were uncomfortable?  I think a teacher ought to learn more about this kind of teaching before they set out to try it and fail.   I mean, what about her students?  I would be discouraged if I were in her class.

We labored as methods course instructors to confront pre-service teachers' insertion of quick fixes, over-simplistic assessments of teaching, and their pressures to make us tell them what to do in a prescriptive fashion. Despite our efforts to offer contrasting models for teaching and alternative interpretations for children's success and failure in science, pre-service teachers largely referred to the conservative interpretations of their public school experiences to guide their pedagogical choices.

Pre-service teachers who embraced conservative, traditional, and didactic approaches to teaching science were identified early by their cohort peers.  Those pre-service teachers who seemed to authentically explore alternatives to teaching were empathetic yet critical of their peers describing them as "shallow" and "resistant." Solumai explained,

Solumai: I can understand clinging to a narrow focus.  "Let me learn about teaching science, that's it.  No more, no less."  For example: Deb O'Brien.  We hated that article because we did not want to admit that there were problems/tensions in the classroom that were beyond our control as teachers.  As a class, we were hampered by a limited interpretation that we could not move past regardless of prompting by the instructor.  Most of us already knew about how we wanted to teach science even though we said, "We don't know anything."

These pre-service teachers who demonstrated the predisposition to explore and be reflective had a difficult time engaging with the majority of pre-service teachers who were gauging effective teaching based upon their own k-12 experiences. Efforts to talk more broadly about children's thinking, lesson planning, and reform issues often degenerated into a negotiation of a shared repertoire embodied in course assignments and deadlines. For example, students with poorer science experiences openly challenged the course expectation to create a lesson to promote deeper content understanding. Pre-service teachers claimed they were unprepared to teach in these ways and unable to learn science because of their prior experiences. Many of these biases were rooted in the premise that "teaching is telling." Ironically, those pre-service teachers who professed the least amount of science teaching knowledge spoke the most authoritatively and critically regarding constructivist teaching methods.

In summary, most pre-service teachers had shared didactic and sterile learning experiences in science. Few had even described a single positive teaching role model that had helped them to understand science content in deeper ways. Most pre-service teachers with a concurrent placement outside of TRIBE described that science instruction was absent or over-simplistic. Despite their enjoyment of example lessons that the first author used to engage pre-service teachers as learners, they continued to offer pedagogical suggestions consistent with their traditional past experiences. Criticisms of videos and exemplary teacher case studies focused around providing children more "structure" and not letting children wander intellectually "too long without providing them with the correct answer."

*Challenge #2: Competing notions of legitimate peripheral participation leave newcomers' identities intact.* The goal of the methods course was to introduce the pre-service teachers into a new community of teaching--complete with new kinds of participation which would contrast traditional teaching approaches with current reform visions Unfortunately, the majority of pre-service teachers focused their efforts on a "what works best for me" perspective. Pre-service teachers of this study were kept in a tight knit cohort group throughout. The science methods course was one of the last courses offered in the program and strong relationships and roles were formed within the group which encouraged pre-service teachers to negotiate the expectations of the program.

The first author was unaware of the strength of pre-service teachers' commitment to existing shared repertoires but he was keenly aware of his newness to the university faculty and desired to understand the learning context. From pre-service teacher focus groups and from notes of our pre-service teacher informant we found the pre-service teachers' joint enterprise #1 of completing course assignments involved negotiating with the professor (a perceived outsider to the community) to lessen the expectations on the group as a whole. The cohort nature of the teacher preparation block had allowed pre-service teachers to establish roles and strategies for influencing course expectations. They negotiated tasks in ways similar to that described by Doyle in pubic school settings (Doyle, 1988). Part of the negotiation that grew out of these roles was an agreed alliance among all students. Typically students who encountered difficulty completing one or

more of the tasks would contact another group through email and an established web listserv to commiserate prior to the next class session.  Groups agreed that together they could lobby for a change in the assignment, deadline, or expectation of completed assignments.  Uniformity was a central tactic presented to new methods instructors. Kent's reference to the way others in the class felt about course expectations was voiced in his journal.

Kent: I feel our frustration level with the class is increasing… Never in my educational career has one class required this much work in a one week period . . . I must be critical of the instructor, I feel it was extremely unfair to give us an assignment of this size and magnitude.  Talking with others in our class, I believe, I am not the only one who feels this way.

The pre-service teachers also launched a well-articulated, timed, and coordinated effort lodging complaints. These complaints were not random or spontaneous by nature. Instead, groups of students met to formulate the best plan of attack.  Email correspondence, formal letters, phone calls, and seminar discussions were coordinated by more than a third of the class so as to maximize the impact.  The underlying message stated by one student was paraphrased as, "It was active lobbying for group effort.  There was enormous social and peer pressure with underlying implication of, 'If you don't call or join in the resistance, you're not part of the group."

While the majority of pre-service teachers did present a seamless front, those who were disheartened with their peers remained silent.  A small minority of the cohort's pre-service teachers did gather separately and discuss the depreciating expectations and concessions made in the course. These pre-service teachers also recognized patterns of behavior in their peers who, in their estimation, were less than serious about their professional preparation. Solumai expressed her frustration with her peers

Solumai: What frustrates me is the minimalist approach my classmates have toward science . . . I have felt that lately, they are less interested in acquiring methodology and more interested in skating by without having to try anything new or face challenges.

One older pre-service teacher of the course echoed Solumai's frustrations with peers asking "Haven't these people ever taken a real college course? You just don't try to avoid course work like that."  Still, the pursuit of negotiations between the pre-service teachers and their methods instructor was led by socially influential pre-service teachers in the cohort. Other challenges to rigor was more subtle but consistent with this kind of resistance.  For example negotiating with the professor to lessen the expectations on the group as a whole was promoted by one of the peer nominated panel members.  Though the instructor had hoped to corral support for high standards through a shared sense of community, students like Arnold who volunteered for the advisory panel lobbied for the position based upon certain savvy, persuasive, charismatic qualities  not necessarily those representing the interests of teaching children successfully. When Arnold's was nominated for the advisory panel, we became concerned for his ability and knowledge of

being able to execute expertly the cohort's joint, resulting in an agenda of enabling pre-service teachers to perform the least work for the most reward. As an example, when Arnold was aware that all members would receive equal grades for group work, Arnold conveniently allowed his group to complete his work without penalty, offering only excuses of weddings, trips out of town, and dates for comprehensive standard achievement tests common to all candidates.

Pre-service teachers' views of mastery in teaching were also influenced by the "expert" teachers they were viewing weekly in their concurrent school site where they would soon teach.  While those pre-service teachers placed with TRIBE elementary mentors (like Solumai, Sam, and Madeline) expressed public gratitude and immediate application of new pedagogy and theory, negotiations with professors reached their peek just prior to the pre-service teachers' beginning to actively teach in the secondary school site (not TRIBE). A formal meeting was called by the University faculty member leading the block who had led the collaboration with TRIBE Elementary for years (but had not met with this cohort of pre-service teachers before due to sabbatical). Concessions in the methods course were encouraged, to squelch the discontent of the majority of pre-service teachers.  Several, such as Kent, commented directly in their journal, explaining that the reduced workload "released tension" reinforcing the cohort's message 'less is more'.

Kent:   I would like to praise the professor for realizing the anxiety of the class with regard to the work load.  Today, he reduced what was due in the remainder of our classes.  This definitely released tension and anxiety in our class.

Since the strategy complaining to the University cohort leader in a week long coordinated attack had apparently resulted in success, the pre-service elementary science teachers' public resistance became more emboldened.

Like findings of other studies (Adams & Krockover, 1999; Freeman & Smith, 1997), many of the pre-service teachers focused their efforts on practical and immediate agendas like completing assignments and constructing survival tactics for teaching rather than focus on more thoughtful intents of the readings, observations, and debriefing exercises that centered on constructivist strategies.  Teachers' self-oriented focus during the course of their teacher preparation often took them on the path of greatest convenience for themselves rather than thinking deeply about course objectives.  Though resistance to creative teaching and learning approaches is often attributed to external forces associated with public education (Clauss, 1999), this orchestrated negotiation was largely fueled internally.  It confirmed Freeman & Smith's (1997) claim that pre-existing negative student attitudes are more resistant to change than the literature on teaching reform initiatives indicate.

Because of the competing communities of practice to which pre-service teachers belonged the first author was less successful in establishing new shared repertoires and sustained mutual engagement around joint enterprises.  We perceived that the joint enterprise of the group of pre-service teachers was to negotiate with their instructors to lower the standards and means of meeting them.  This kind of participation was

illegitimate from our perspective. Conversely, the first author promoted a joint enterprise of questioning past educational experiences and notions of teaching that pre-service teachers perceived as illegitimate. Our findings give weight to Lave and Wenger's (1991) claim that conferring legitimacy in roles and mutual engagement is central to newcomers' indoctrination, It should be clear that, in shaping the relation of masters to apprentices, "the issue of conferring legitimacy is more important than the issue of providing teaching" ( p. 92). The pre-service teachers did not grant the first author legitimacy and instead interpreted his actions as out of touch with their reality.

In summary, as an experienced professor new to the setting, the first author set out to present an alternative representation of teaching science but the pre-service teacher cohort had pre-determined roles comprised of contrasting beliefs about teaching that were played out in a negotiation with the instructor to change the face of the methods course. Instead of focusing on ways to raise the bar, pre-service teachers used their knowledge of the political hierarchy and unified presence to pass blame on to the outsider to the community—namely the methods instructor demanding high standards. Pre-service teachers were unable to differentiate between what assignments were useful or which approaches were thoughtful ways to engage children in thinking about science.

*Challenge #3: Logistic constraints contributed to the resistance to changing beliefs about teaching.* Several teacher educators have argued that partnership relationships between schools and universities are a key factor in determining the kind of influence teacher preparation has on pre-service teachers (Cuban, 1993; Ball, 1988; Abell et al, 1998; Lieberman & Miller, 1999; Lortie, 1975). We were unable to place all of our students within the TRIBE school for their concurrent  placement though we were able to engage all of our students 6 hours weekly in TRIBE classrooms, observing science lessons, planning and teaching their own inquiry lessons, and reflecting with TRIBE teachers, peers and methods instructor.  Pre-service teachers who were not placed at TRIBE School for their concurrent placement (an additional 20 hours weekly) did not consider the practices of TRIBE teachers, methods instructors, and student teachers to be legitimate but rather turned to the conservative approaches of their Master Teachers in other school placements.  In this way students attended to their joint enterprise #3 of maintaining their identities--embracing repertoires similar to their own public school experience to and citing factors in their school placement as the primary influences over their pedagogical choices.

It was clear from our conversations with teachers in non-TRIBE schools that science would not be incorporated into their curriculum or their expectations of pre-service teachers under their direction—at least during the time of their university placements.

Tony:   I have never been asked to teach science and we never get to see science taught in the classroom we are assigned.  We only rarely see mathematics taught and when we do it's just worksheets.

Kent:   The fact [is that] none of us have taught science, or [have even] seen it being taught in a classroom.  [This makes the unit planning] entirely difficult to implement.

The school context for most students was not conducive to reinforcing inquiry teaching for science.  In fact, it was rare for students to be able to observe science taught at all in the schools.  Once in a while students observed worksheets being completed by children but that was the extent of science instruction.  A "literacy" policy was invoked requiring teachers in every school to teach decoding, guided reading, text interpretation, and other specific reading domain skills for the period of 8am-11am daily.   Many students reported that their teachers were afraid to teach any other topic during this time as they had been threatened by their local administrator to stay within the guidelines. The symbiotic construct that students were ill-equipped to teach science (Challenge #1) and the implication that they were unable to influence the local curriculum and administration mandates, reinforced pre-service teachers identity of "I need to be told what to do" as a way of managing their joint enterprise #1. While some students pointed to their inexperience as the excuse for their lack of initiative in trying new ways of teaching, others were more explicit about their expectations from methods course instructors.

Despite the openness to other strategies for teaching science and opportunities to watch and participate in teaching inquiry lessons and receive support and feedback during their planning and teaching, pre-service teachers used the conservative and more deficit model of teaching to guide the interpretations of their experiences.  Clearly, pre-service teachers immersion and partial practice in another community was not sufficient for shifting their identities.   Lave and Wenger (1991) argued this is likely because, "activities, tasks, functions, and understandings do not exist in isolation; they are part of a broader systems of relations in which they have meaning…thus identity, knowing, and social membership entail one another… Legitimate peripheral participation refers both to the development of knowledgeable skilled identities in practice and to the reproduction and transformation of communities of practice.  It concerns the latter insofar as communities of practice consist of and depend on a membership, including its characteristic biographies/trajectories, relationships, and practices.  Continued practice in another more conservative community resulted was a rejection of the TRIBE context as inauthentic and illegitimate.  Many pre-service teachers described the TRIBE school as unrealistic and an isolated case that would fail to function in other "more realistic" environments.  Such pre-service teachers largely reverted back to the notion of teaching as carrying out instructions and following guidelines that are provided from above.

Perhaps the most positive aspect of the methods course for these pre-service teachers was the opportunity to try out their planned units and the related methods of teaching at their afternoon school site. Each pre-service teacher had the opportunity to teach six lessons after extensive planning to address students' alternative science conceptions.  Though most pre-service teachers found this experience valuable, they interpreted their success from conservative and traditional perspectives.  Most students focused on children's affect (e.g.: children smiling, raising hands, and offering correct answers) while paying little attention to the sense making and cognitive processes of the

children.  The goal of making science fun took precedence over children's' understanding of the concept.

Chris: …We took the students outside and launched a water rocket... This was a fun way to conclude our lessons…The strength of my lesson was that is was hands on for the students. The weakness of my lesson was that the students may not have understood the main idea of the lesson…Next time… I will give precise directions for what the students should be observing [before handing out parachutes].

Pre-service teachers largely began building a system for devaluing science inquiry in school.  In their minds, if the district mandated their time in a way that excluded science from the curriculum, then there was no recourse.  Most often, pre-service elementary science teachers would plead ignorance about how to revise their lesson plans in accordance to the syllabus expectations.  Pre-service teachers would respond with "I don't know what I would do.  Please tell me because I never was good at science.  How am I supposed to do this?"  However, if the advice of the professor was outside the domain of teaching as telling, students would offer a plethora of reasons why it could not be done.  "My teacher doesn't teach science", "I hardly know these students." "It takes too long and we have to stay with the curriculum at our school". Arnold was confused about the accuracy in his preparation and implementation of his lessons.  Arnold's insecurities branched from not having clear critiques of his use of newly learned reform theory.

Arnold: We don't understand if the corrections we made [on our lesson plans] are right or wrong.  I don't know if the lessons we are teaching [in classes currently] are right or wrong…The problem is that there is such a focus on literacy that science teaching gets bumped.

Kent: The fact [is that] none of us have taught science, or [have even] seen it being taught in a classroom.  [This makes the] project entirely difficult to implement.

In essence, pre-service teachers claimed they did not know how to teach science until confronted with their beliefs and then proposed a variety of "informed" reasons inquiry teaching was flawed or inappropriate for their concurrent placement.. Below, Janice explains what she perceives the role of a science methods instructor to be:

Janice: I think that's [good science teaching exposure] what the methods course teacher is supposed to tell me.. [how can I] teach well if I've never had any good models and no one is telling me what I need to do?"

Clearly this response lies outside of the realm of total ignorance or lack of opinion towards good teaching.  This student represented the strong opinions of many classmates who saw the role of the methods instructor as one of prescribing straightforward advice and small adjustments to their preconceived notions of science teaching.  Many pre-service teachers used language of received knowing (Hogan & Clandinin, 1993) and forfeited the responsibility of learning to teach in other ways.  Despite the  lessons

demonstrated in methods class geared specifically to their topic, support in exploring their students' alternative conceptions of the scientific topic, feedback on their planning and student interviews, pre-service teachers continued to demand to be told specifically what to do during their teaching at their concurrent school site.

Despite having been taught to promote student-centered instruction, only a few students left the course professing to value teaching for deeper conceptual understanding. The science instruction pre-service teachers had received and enjoyed during the methods course, did not necessarily apply to their experiences teaching children.  Naturally, this dichotomy between philosophy and practice eventually surfaced as a tension that pre-service teachers struggled with, though they did not necessarily recognize what they struggled against.  Some pre-service teachers, however, did take on some of the shared repertoires of science inquiry teaching and engaged mutually in reflecting upon the difficulty of unlearning old repertoires and enterprises. As Tony described, "it wasn't until I experienced [through observation and application] it [inquiry based instruction] that it became concrete and vital to my teaching style."

Solumai accepted a position teaching science, just weeks after her completion of the methods course.  We were able to keep in contact with her and many of her peers who were successful in science methods at TRIBE.  In her reflection on her changed philosophy statement Solumai continued to journal, internalizing the readings and class discussions from her methods course.

Solumai: …I feel that I achieved a measure of success in the course mainly because I am still in the process of taking the course in some way.  As I continue working on the implementation and the refining of my ideas about teaching philosophy, I realize that there are many ideas from the course that I have not yet tapped into. In fact, I occasionally think about articles we read as I reflect on the issues I face in my classroom and my sense-making  …I think about the articles…[In my] reflect[tions] of how I teach and what the students understand.

In the end, pre-service teachers who were successful in their instruction and synthesis were noticeably bothered with their peers' choices to avoid making principled, thoughtful decisions about curricular and pedagogical choices. Madeline blamed choices made by her peers on the difficulty of authentic conceptual change. Solumai cited that collaborating teachers and minimalistic mentality are reasons for a lack of conceptual change in her peers.

Solumai: Madeline and I struggled with the rest of the class as a whole; we felt that their resistance was the product of the minimalist mentality rather than resistance based on any foundation, whether theoretical or practical. [My peers] found Kohl to be highly motivating, yet turned around and said, 'But I can't teach science that way, that's not how it's done in city schools right now.  I have no say whatsoever.'  I understood the sense that [my peers] were under the pressure of their collaborating teachers, and maybe teaching at [the second school] did not change that context for them.

Madeline: Conceptual change is as difficult a process for adults as it is for young science students.  I see our own class as evidence to support this both in their scientific thinking and their beliefs about teaching in general.

## Discussion

While we as teacher researchers do not ascribe to the artificially imposed dichotomies of practice and theory, we must recognize that our attempts to change the practices of pre-service teachers who spent only part of days in a rich collaborative context were heavily influenced by the advice of traditional teacher/mentors and socialization forces of classrooms where they spent the rest of their days.  We designed the methods course so  pre-service elementary science teachers could engage in Legitimate Peripheral Participation in a Community of Practice  where master teachers exhibited inquiry-based practices and reflected with pre-service teachers about what they were doing.   However, limits in the ability to place all pre-service teachers in concurrent teaching positions within TRIBE school where methods, observations, and other coursework were facilitated impacted the uptake of inquiry science teaching repertoires and their views of who held "teaching expertise". The majority of  the pre-service teachers maintained their original interpretations of successful teaching even after practicing reform methods in a supportive environment. As a result, the LPP that was intended to foster a constructivist learning orientation in the cohort created a wide variety of interpretations and applications of reform teaching with diverse outcomes.

Moreover, the inability to place all students at TRIBE Elementary to work full-time with inquiry-oriented mentor teachers impacted the process of facilitating changes in beliefs and practices.  Instead of contrasting pedagogies being embraced and practiced by pre-service teachers, only those who were placed with mentor teachers who took time to teach science in the elementary school in spite of the major push for literacy were able to put into practice constructivist methods with children. Ideally, in identifying mentor teachers for the concurrent placement, care would be taken to insure that they were modeling the practices being taught in the methods courses. Logistically this could not be accomplished during the study given the number and availability of schools and teachers willing to support our pre-service teacher's in field-based settings.  When pre-service teachers perceive traditional teachers as "masters" because of predispositions from conservative, didactic learning experiences, in-roads into changing teachers' beliefs and practices are difficult at best.

What was clearly evident and troubling to us was the freedom some pre-service teachers felt to limit and influence their apprenticeship which affected  the entire cohort. Lortie (1975) described such socialization forces which shape accepted beliefs and practices and warns of the resulting effects on the quality of teaching.  Rodriguez (1998) argued that necessarily these need to be addressed directly and explicitly if inroads are to be made in science classrooms.  Otherwise not only do pre-service teachers choose not to adopt or even consider seriously alternative strategies presented in methods course, such

pre-dispositions heavily influenced the kind of legitimate peripheral participation experienced by their colleagues at schools like TRIBE.

Implications

Few would deny that current reform calls for teachers to rethink and fundamentally change some of their approaches to teaching science. A potential problem can develop however, when teachers themselves have not had learning experiences upon which to model new instructional strategies. From our participation in field-based methods courses we perceived the need to engage novice science teachers in a variety of supportive learning situations that challenge traditional conceptions of what it means to teach and learn science.

This says much about the abilities for new teachers to be change agents in schools. The role of socialization and context is powerful. This is of great concern because we largely believe that schools need to change, in the words of the Glenn Report "Before it's too late" (US Dept. of Education, 2000), but preparing large numbers of elementary teachers with example practices separate from authentic contexts will not result in large scale change. Though we have come a long way in recent decades to recognize the complexity of knowledge required by expert teachers and we are carving out ways in which to impart that knowledge to future teachers, we must acknowledge that this takes more resources, time, and expertise than literature suggests is currently available in schools. As Ball, Lampert, and Rosenberg (1991) have argued, "learning to teach entails developing ways of looking and listening, ways of interpreting and reasoning, as well as ways of being and doing (p. 269)." If we want to cultivate reform, we need to develop contexts where pre-service teachers are immersed in inquiry-based environments rather than depending on the piecemeal approach experienced by the pre-service teachers described in this study.

Alongside these revelations, we must recognize the strong socialization processes that attract the membership of future teachers as well as guide them in the field as our surrogates. Novice science teachers have arguably limited ways of viewing teaching from the perspectives of pedagogical choices, student knowledge, or the nature of science. In order to understand and appreciate the complexity and difficulty of teaching for understanding, novice teachers need to experience teaching in authentic contexts. In addition, novice teachers need to be supported to recognize how their own experience in education can be reframed and transformed through critical reflection. University teacher educators cannot function alone in their preparation of future science teachers.

For this vision to come to pass, coordination must occur amongst teacher preparation institutions and public schools. A more systemic approach for the continuous and significant improvement is needed for the preparation, induction, and professional development of teachers. This process needs to empower all members and foster the development of exceptional schools. The reality that teacher educators work within often contrasts with these visions. We must operate in contexts we do not understand or know how to support. We must work with a limited number of teachers we truly trust as

expert--fostering communities of practice in which new-comers can observe and partake in common ways of thinking, speaking, acting, and reflecting.  We need to create a "culture of practice" that embraces observation, participation and ways of engaging with reform teaching and learning. New comers' legitimate peripheraility provides them with more than an "observational" lookout post:  It crucially involves participation as a way of learning--of both absorbing and being absorbed in --the 'culture of practice.' Lave and Wenger, 1991 p. 95).

These and other special considerations of preparing future teachers should be the subject of future studies.  Smith (1999) and others (Simmons, et al., 1999) have warned us about the need to carefully consider the kinds of experiences our pre-service teachers bring to the profession.  Not only do they bring inadequate scientific knowledge to teach children, but they also bring a variety of beliefs which drive the profession toward conservative models of instruction.  Likewise, we cannot assume that because pre-service teachers are learning science in our classrooms that placing them in public school classrooms will result in successful implementation of our methods.

This study expresses the need for extensive dialogue among teacher educators regarding the context into which we insert new science teaching professionals.  When professors bring with them to teacher education programs a rich environment for meaningful discourse, it creates a design of quality university programming. Beyond these programs, support needs to follow in the form of available expert teachers in the field. Regular discussions and re-evaluation of the university experiences and partnerships with expert teachers are crucial to linking theory and practice.  If faculty are unable to work together within colleges of education and maintain similar roles and relationships with the community public schools, the integrity and effectiveness of the teacher education program weakens.

Collaboration, however, does not simply mean providing a classroom venue and a warm body as a Master Teacher. Collaboration within universities and schools translates into actual practices and sustained support for intended change. Collaboration of professors better supports a symmetrical experience for all candidates while different professors are required to teach similar courses.  We believe that improvement within the ranks of teachers begins with their pre-service experience and we feel it is essential to limit the number of "escape routes" for minimalist students.  Further, one of the purposes of a teacher education institution should be to shape teachers' beliefs about teaching and learning and mold their interpretations about their role in their own professional development.

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Appendix

Brief Description of Elementary Science Methods Readings and Activities

*Tentative Course Schedule*

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**Week #1**                                                    **(January 24th)**
**What is our experience as learners?**
**Readings Due:**
- Syllabus
- Watson, B. & Konicek, R. (1990).  Teaching for conceptual change:  Confronting children's experience.  **(In class)**

**Assignments Due:**
- Quickwrite #1  "What is Deb's problem?" **(In class)**
- Outline of pedagogical autobiography  **(In class)**
- Selection of topic for clinical interview and lesson **(In class)**

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**Week #2**                                                    **(January 31st)**
**What does it mean to *know*  a scientific concept?**
**Readings Due:**
- Roth, K. (1987).  Learning to be comfortable in the neighborhood of science.
- Howe, A. (2001). *Engaging Children in Science, Chapter 1 & 2* Science as a Human Activity, and Children's Thinking and Learning.

**Assignments Due:**
- Quickwrite #2 **(In class)**
- Five Questions to ask children in your clinical interview  **(Homework)**
- Draft pedagogical autobiography **(Homework)**
- Student interview protocol and engaging event  **(In class)**
- Service Topic **(In class)**

**To assist your pedagogical autobiography**
   Related questions:
      How comfortable are you in the neighborhood of science?  What neighborhood are you comfortable in?  Do you dance, write, cook, compete athletically, paint, or something else which requires a wealth of other kinds of knowledge?  Once you have considered how well you do or don't know science, explain how knowing something deeply differs from your knowledge of science learned in school or your past science experiences.
      What kinds of teacher preparation and teacher growth issues are related to knowing in this kind of way?  How do you go about learning science in the same way you know something deeply?  Is it important to know science deeply in order to teach it to children?

Where do teachers acquire this kind of knowledge?
(Unacceptable answers include: "I just need teaching experience. I'll learn it from my mentor teacher. It just comes from working in the classroom.") What is it that you need to do to improve you knowledge? What specific items might be included on a plan for your long-term professional development?

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**Week #3**                                                     **(February 7th)**
**What do children know?**
**Readings Due:**
- Anderson & Smith (1987) *Teaching Science*.
- Howe, A. (2001). *Engaging Children in Science, Chapter 3.* Integrating Science Content and Process.

**Assignments Due:**
- Final pedagogical autobiography **(Homework)**
- Three example activities on teaching topic **(Homework)**
- Activity critiques (3) **(Homework)**
- Practice interview with peers or children **(Homework)**
- Final interview protocol and engaging event **(In class)**
- Practice student interview report **(In class)**
- Quickwrite #3 **(In class)**
- Draft concept map of science topic **(In class)**
- Topic and venue for interviewing complete **(Homework)**

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**Week #4**                                                    **(February 14th)**
**What to teach?**
**What's available?**
**What's appropriate?**
**Readings Due:**
Howe, A. (2001). *Engaging Children in Science, Chapter 4 & 5* Teaching Basic Science Skills.
 and Teaching Science as Inquiry.

**Assignments Due:**
- Revised lesson on topic **(Homework)**
- Permission letter **(Homework)**
- Revised concept map of science topic **(Homework)**
- We b resources 5 on  and 5 off topic with brief explanations **(Homework)**
- Quickwrite #4   **(In class)**
- Revision #1 of coordinated lessons  **(In class)**
- Interview 3 or more college students  **(In class)**

- Practice interview results **(In class)**

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**Week #5**                                                                **(February 21ˢᵗ)**

How do I know students understand?: Objectives and student task engagement
**Readings Due:**
- Howe, A. (2001). *Engaging Children in Science, Chapter  6 . Teaching Science to Promote Independent Learning.*

**Assignments Due:**
- Interview 3 or more children **(Homework)**
- Interview analysis writeup first draft **(Homework)**
- Final concept map **(Homework)**
- Quickwrite #5  **(In class)**
- Second revision of lessons **(In class)**

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**Week #6**                                                                **(February 28ᵗʰ)**
**What do I need to know?**
**Readings Due:**
- Kohl, H (1984). *On Growing Minds*  Chapters 1-5
- Howe, A. (2001). *Engaging Children in Science, Chapter  7 & 8*   Enhancing Instruction through Assessment  and Planning for Achieving Goals.

**Assignments Due:**
- Final interview analysis writeup **(Homework)**
- Concept for Learning Center  **(Homework))**
- Presentation of Interview Results (In class)
- Quickwrite #6  **(In class)**

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**Week #7**                                                                **(March 7ᵗʰ)**
My preparation:  How prepared am I and where am I going to learn the rest?
**Readings Due:**
- Howe, A. (2001). *Engaging Children in Science, Chapter  9 & 10*  Shaping the Classroom Learning Environment and  Including All Children in Science.
- Kohl, H (1984). *On Growing Minds*  Chapters 6-10

**Assignments Due:**
- Articles Found (2) **(Homework)**
- Article discussion **(In class)**
- Learning Center Materials  **(Homework))**
- Draft Learning Center **(In class)**
- Midterm Exam   **(In class)**
- Quickwrite #7  **(In class)**

**Week #8**                                                            **(March 14th)**
**How do I gauge my performance?**
**Readings Due:**
- Howe, A. (2001). *Engaging Children in Science, Chapter   11 & 12*   Integrating Science with Other Subjects.  and Taking Science beyond the Classroom.
- Kohl, H (1984).  *On Growing Minds*  Chapters 11-16

**Assignments Due:**
- Quick write #8 **(In class)**
- Article critiques (2) **(Homework)**
- Social, cultural, historical background of your topic **(Homework)**
- Second revision of lessons **(In class)**

**Week #9**                                                    **(March 21st)**
**What is important to reflect upon?**
**Readings Due:**
- Howe, A. (2001). *Engaging Children in Science, Chapter   13* . Learning Science with Computers.
- Kohl, H (1984).  *On Growing Minds*  Chapters 17-22

**Assignments Due:**
- Quick write #9 **(In class)**
- Diversity component draft in lessons **(In class)**
- Final revisions of lessons including diversity component **(Homework)**
- Practice peer critique of lesson **(In class)**

**Week #10**                                                  **(March 28th)**
**What are my values teaching science?**
**How does my cultural knowledge and experience affect my teaching?**

**Readings Due:**
- Kohl, H (1984).  *On Growing Minds*  Finished
- Ball, D. & McDiarmid, G. W. (1991).  Why staying one chapter ahead doesn't work.

**Assignments Due:**
- Teach science lessons 1 and 2 in classrooms  **(Homework)**
- Videotape and watch science lessons 1 and 2 in classrooms  **(Homework)**
- **Journal Entry "How did you do?"  "How do you know?"**
  - *Quick write #10  **(In class)***

**Week #11**                                                        **(April 4th)**
**How are my efforts to manage classrooms sensitive to all students?**
**Factors mitigating success for all**
**Readings Due:**
- Jackson, P. (1992).  The practice of teaching.
- Ayers, W. (1993). *To Teach* Chapters 1-3

**Assignments Due:**
- Teach science lessons 3 and 4 in classrooms  (**Homework)**
- Videotape and watch science lessons 3 and 4 in classrooms  (**Homework)**
  - *Quick write #11  (**In class)***
  - *Peer feedback for lessons 1 - 4 (**In class)***

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**Week #12**                                                       **(April 11th)**
**Competing agendas in school:  Where do I turn my attention?**
**Readings Due:**
- Michaels, S. & O'Connor, M.C. (1989). Literacy as multiple discourse.
- Ayers, W. (1993). *To Teach* Chapters 4, 5

**Assignments Due:**
  - *Quick write #12  (**In class)***
- Teach science lessons 5 and 6 in classrooms  (**Homework)**
- Videotape and watch science lessons 5 and 6 in classrooms  (**Homework)**
- Peer critique for each member  (**In class)**

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**Week #13**                                                       **(April 18th)**
**The role of the university in learning to teach.**
**Readings Due:**
- Lampert, M. (1985).  How teachers manage to teach.
- Driver, R. et al (1994).  Constructing scientific knowledge in classrooms.

**Assignments Due:**
- *Quick write #13  (**In class)***
- *Revised lesson plans*
- *Self assessment/Response to peer feedback  (Homework)*

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**Week #14**                                                       **(April 25th)**
**Looking Beyond: What's next?**
**Readings Due:**
- Aikenhead, G. (1996).   Border crossing into the culture of science. *Journal of Research in Science Teaching*

- Ballenger, C. (1995). Because you like us: the language of control. *Harvard Educational Review, 62*, 199-208.

**Assignments Due:**
- *Quick write #12  (**In class**)*
- ***Assessment of children's learning***

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**Week #15** (**April 30**[th])

**Assignments Due (In electronic format \*.doc ):**
- Final Lesson Plans (3) With Diversity Component
- Interview analysis with transcript
- Correlation of interviews/pre-post assessment/lessons

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