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**PRE-SERVICE SCIENCE TEACHERS' SELF-PERCEPTIONS OF MEMBERSHIP IN
MULTIPLE COMMUNITIES OF PRACTICE:
HOW SELF-IDENTITY AWARENESS CAN INFORM TEACHER EDUCATION**

A Thesis in
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by
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ABSTRACT

Pre-service science teachers were videotaped during a micro-teaching activity with small groups of middle school students and were asked to reflect on the activity. This study analyzes pre-service teachers' oral and written reflections using cultural-historical-activity-theory (CHAT) and sociolinguistics. An inductive, category-generating process was used to code the observational foci of those reflections, which found that pre-service teachers attended to the science of the lesson, actions of the teachers and students, and observations about both teachers and students as learners. The reflections were then coded according an identity framework in which pre-service teachers identified themselves as students, teachers, and scientists. Pre-service teachers most often attended to the science content of their lessons, but they most often identified themselves as teachers rather than as scientists or students. This study proposes how reflective practice can be used to transform pre-service teachers' identities into that of reform-based teachers (Luehmann, 2007) who blend multiple communities of practice into one community of reform-based teaching.

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PREFACE

For many, childhood, adolescence, and the emergence into adulthood can be described as a incessant effort to find one's identity. As a Vietnamese-American, not-quite-Buddhist child growing up in Anglo-Saxon America, I struggled in my search for identity and belonging. In mental dialogues with my conscience, I wondered: Why should I speak a different language at home? Why don't I have blond hair and a name like "Melissa"? Why do we get time off school for Good Friday and Easter? I often wondered how life would have turned out differently if someone had given me *Cliff's Notes* for "Finding Yourself." Would I have spent as much time worrying about fitting in? Would I have spent less time angry at my parents for not naming me "Melissa" or for expecting me to speak Vietnamese at home?

After receiving a bachelor's degree in physics, I began a postbaccalaurate teacher certification program and again found myself between worlds. I used to consider myself a hard scientist; I am a student again; I am going to be a teacher. The term "student teacher" seemed somewhat ironic: How can I teach students if I myself am still a student? I thought I had left behind the nebulous searching-for-identity phase of adolescence; again I had to negotiate a role for myself in this new community at graduate school. Although the experience was not quite as difficult as adolescence, I encountered more conflicts than I expected, and these conflicts seem to be shared by other pre-service teachers in their programs. We continue to confuse our roles in our different communities, especially in this digital age of Facebook, MySpace, Twitter, and other online social networking applications. As a

student, I felt obligated to have and maintain a Facebook profile listing all the aspects of my personal life, replete with photographs. As a teacher, the stories and rumors of teachers and other professionals who were fired or never hired for material appearing on their Facebook or MySpace pages made me feel dirty for even having a Facebook account. Pre-service and beginning teachers most likely share these conflicts; or, if they do not recognize such conflict, they may find themselves in compromising situations.

How can teacher education be improved to recognize and attend to the conflict of identity of pre-service teachers? Can the process of resolving identity conflict add to or help to refine teachers' professional vision (McDonald and Kelly 2007)? And, as a result, can teacher education programs "streamline" pre-service teachers' negotiation of their new roles as professional teachers?

Traditionally, professional practitioners (i.e., in-service teachers) and educational researchers (specialists in sociolinguistics, psychology, etc.) carry out research in education, and faculty of teacher education programs at universities conduct research in teacher education. As a pre-service teacher and graduate student doing research about other pre-service teachers and undergraduate and graduate students, I hope that my findings are not too presumptuous but that they help to refine teacher education for students in the same walk of life.

INTRODUCTION

This study explores how pre-service science teachers regard themselves as individuals, in which communities they perceive membership, and how this self-perception can inform teacher education. To highlight these relationships, this thesis is organized in two separate parts. Part One elucidates the concepts necessary to gain an understanding of the study. Chapter One defines reflective practice and determines how it can be used to evaluate the thought processes of a professional teacher. Chapter Two outlines communities—specifically communities of practice—and their relationships to activity theory. Chapter Three defines identity in terms of these communities of practice using activity theory. Finally, Chapter Four ties together Reflection, Community, and Identity in a discussion about conflicts in the practice of teaching, especially conflicts faced by novice (pre-service) teachers. In Part Two, I describe the study of pre-service teachers' reflections about a micro-teaching activity (“teaching clinic”) required as part of a science education methodology course and discuss how their self-identifications can inform and improve teacher education.

PART ONE

THEORETICAL CONSTRUCTS

Chapter 1. Using Reflection

Teacher education, from the perspective of a prospective teacher, involves learning content (e.g., physics concepts), pedagogy, and professionalism. Learning content and pedagogy can be described as answering the questions: “What do I teach?” and “How do I teach it?” These questions focus on the role of the prospective teacher as *the* teacher in the classroom environment. Learning to be a professional, on the other hand, requires the prospective teacher to consider herself a member of a community of practitioners—professional teachers—who must learn and follow the pre-established practices of that community and see the world through the lens of the professional vision of teaching (McDonald & Kelly, 2007). The professional teacher is not solely a teacher; the professional teacher is also a student of the profession. So, although completion of a teacher education program and receipt of a teaching certificate may officially mark the end of a professional teacher’s educational career, the true professional teacher is a lifelong student who continues to learn from experience *and* reflection.

What is reflection, and why use it? Reflection as a concept began with the works of John Dewey, who recognized that teaching is not an exact science; Schön refers to that outdated model of prescriptive teaching as “technical rationality” (Schön, 1983). In other words, there are no set procedures for particular events, problems, or conflicts; there are no prescribed “rules of practice” in teaching; and theory cannot be mapped exactly into practice (MacKinnon & Erickson, 1992, p. 194). Barnes (1990) describes teaching as

a highly skilled activity which requires of the teacher an immediate response to events as they develop.... The teacher must judge instantly whether the moment requires a suggestion, an invitation to explain, a discouraging glance, an anecdote, a joke, a reprimand, or the setting of a new task. These immediate decisions depend necessarily on intuitive judgment.... (as cited in Barnes, 1992, p. 10)

Teachers must draw from their own experiences and values to deal with a given situation. Novice teachers rarely have a broad enough breadth of skills that allow “fast, fluid, and flexible behavior” that expert or proficient teachers do (as cited in Borko, Bellamy, & Sanders, 1992, p. 50), which come not only from years of teaching experience but also from reflecting on that experience. In fact, novices and experts alike may fail to recognize problems as such without reflective practice (Schön, 1983).

Dewey originally described reflective thought as “active, persistent, and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it and the further conclusions to which it tends” (as cited in Sezen, Tran, McDonald, & Kelly, 2009, p. 2). Schön (1983), drawing on Dewey’s definition, further classifies distinct stages or types of reflection: reflection-*on*-action, which involves reviewing an activity after its occurrence, and reflection-*in*-action, which involves examining an activity as it happens. Thompson and Thompson (2008) add one more category: reflection-*for*-action, which prepares the practitioner for an activity that has not yet occurred. The three types of reflective practice each serve their own purposes, but in each case, reflecting requires the

practitioner to think and analyze deliberately and to be self-aware (Thompson & Thompson, 2008, p. 19). Reflection is not random or arbitrary thinking but rather analytical, critical, and sometimes creative thinking (p. 39).

As professionals, what causes us to want or need to reflect? Why must we think about and analyze our actions? Often, the veteran practitioner becomes comfortable in the stability of his or her practice and goes into “autopilot.” Problems or conflicts can be ignored or unrecognized. This is especially true in the profession of teaching, which has traditionally and erroneously been viewed as an apprenticeship. The so-called standard operating procedures only seem standard because they have never been questioned: “If it ain’t broke, why fix it?” Implicit or “closed” knowledge affects a teacher’s actions and decisions subconsciously (Thompson & Thompson, 2008, p. 23) without deliberate attention to the biases, prejudices, misconceptions, or other issues, that may exist in the teacher’s environment or background. To the novice teacher, whether pre-service or newly in-service, everything may seem like a problem or conflict, and he may feel overwhelmed with what seems an insurmountable amount of unresolved questions.

Both the expert and the novice teacher’s difficulty is not only in solving a certain problem but also in recognizing one. As Schön notes: “In real-world practice, problems do not present themselves to the practitioner as givens. They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain....He must make sense of an uncertain situation that initially makes no sense” (Schön, 1983, p. 40). The practitioner must learn to *problem-set* before he can learn to *problem-solve*. He must analyze or examine the

situation in order to make sense of it (Thompson & Thompson, 2008, p. 35) and *name* the entity to which he will attend (Schön, 1983). This allows genuine conflicts to be accepted as such and lower priority to be given to less pressing issues. The identification of a conflict must be *framed* within a certain context (Schön, 1983): “How will I use what I know as a professional to resolve this?” Reflective practice can help the practitioner to elicit reiterations and commonalities in everyday practice in order to form a meaningful picture (Thompson & Thompson, 2008, p. 35) from the confusion that preceded it. Reflection allows us to “produce a situation that is clear, coherent, settled, harmonious” (MacKinnon & Erickson, 1992, p. 196). Ongoing reflective practice should not be used to generate prescribed solutions to problems; rather, it should expand the practitioner’s framework of “disciplined subjectivity” (as cited in Schön, 1983, p. 116). The professional teacher improves his practice by learning from experience; he learns by reflecting on and in his experience for future experiences. An expert teacher is a lifelong student of his own teachings through reflection.

By assignment and definition, the pre-service teachers’ reflections in this study fall into the reflection-*on*-action category, though some reflect-*for*-action. The reflections are not meant to be evaluated on the basis of their “quality” (e.g., depth, critique, self-inquiry, etc.). Naturally, these novice teachers will, in general, lack the ability to reflect in the manner that Schön proposes; although no direct evidence exists that they have reflected-*in*-action, we should not disregard the possibility. Rather, we will regard their reflections as an introduction to the practices of teaching and reflecting about teaching.

Chapter 2. Learning as a Social Activity

Traditionally, teaching and learning was believed to be the simple transmission of information, and the only interaction of importance was between one teacher and one student. The emphasis on individual learning has diminished since the introduction of the ideas of mediated activity and environmental influence on learning by Vygotsky and other Soviet scholars of the time, who were no doubt influenced by socialist community-oriented views. These scholars recognized that the teacher and student do not exist in isolation. The emergent socio-cultural theory of learning has revolutionized how teachers teach, and studying the interactions of all members of the classroom community and the greater community can help us to refine the practice.

Communities of Practice

Today's classroom is recognized as a global community. This community is not only situated within the physical walls of the classroom but also in the interactions of its constituents. These interactions affect and are affected by nonvisible connections as well—between the students, their parents, the school administration, members of the local community, and professionals and organizations whose standards and practices help to form classroom policy (for example, the *National Science Education Standards*, state departments of education, teachers' unions, etc.). Because of the broad definitions and nebulous boundaries of the aforementioned communities, I will develop a definition to help us gain

understanding about a community's structure and its ramifications on how we teach and learn.

A more appropriate and applicable way to study school communities is by regarding them as *communities of practice*, which Wenger (1998) defines as those that have the following aspects:

- *Mutual engagement* between all members of the community—participation does not have to be equal in amount but must be common to all;
- *Joint enterprise* that is defined by the members of the community, whether explicitly or implicitly, consciously or subconsciously; and,
- *Shared repertoire* or resources, which can be the language or lingo used, daily habits or actions, and so forth.

A major component of the shared repertoire and of any practice is *discourse*, by which I mean language—whether spoken, written, or tacit—that affects the activity or practice at hand. One should note that this definition differs from Gee's (2001) use of the term *Discourse* with a capital D, which he uses to mean specific uses of discourse and associated social practices within a particular community of practice. In this discussion, I will use the term *communities of practice* and reserve the term *discourse* to mean the language use. *Practice* may consist of "language, tools, documents, images, symbols, roles, specified criteria, procedures, regulations, contracts....[It] also includes implicit relations, tacit conventions, recognizable intuitions, perceptions, sensitivities, understandings, assumptions, and shared world views" (Wenger, 1998, p. 47). Shared repertoire, discourse, and practices are not

interchangeable terms, but they are in fact related: They may be visible and tangible or subtle and implied, and they each may impact one another overtly or obliquely.

We can see now that the idea of teaching and learning as a simple interaction between one teacher and one student is no longer valid. A teacher may ask a student a question, but that question is heard and interpreted by others, building a knowledge base of classroom procedures. For example, when the teacher asks a question and awaits a response, other students recognize that responses follow questions. When building this knowledge base, the teacher and students share the joint enterprise of education—which could mean learning a specific subject area or may simply mean completing another day in the classroom.

Another, perhaps more relevant, community of practice to consider is that of the professional community of teachers. Although this community may not reside in the same geographical bounds as the classroom teacher, its actions, values, and repertoire have just as much impact on the teacher as his or her immediate surroundings. The repertoire shared by this community includes the professional standards as set forth by such institutions as the National Research Council and its *National Science Education Standards*. These standards—the repertoire of the professional community—are part of the community's professional vision (McDonald & Kelly, 2007). According to Goodwin (1994), professional vision “consists of socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group” (p. 606). There is no empirically derived, proven theory of teaching, but the *Standards* is a visible,

tangible, explicit expression of the teaching community's shared repertoire of skills and goals.

Understanding teaching in the context of a community of practice—in this case, the professional community of teachers—can help the novice teacher to develop cogent and coherent goals and to avoid or be able to resolve—to reflect-*in*-action—everyday classroom events. Reflective practice then has the framework of the community's values to make sense of these daily dilemmas. “[The] ability to see a meaningful event is not a transparent, psychological process but instead a socially situated activity accomplished through the deployment of a range of historically constituted discursive practices” (Goodwin, 1994, p. 606); incidents can be *named* and *framed* (Schön, 1983) within the context of the professional teaching community of practice and its professional vision. Novice teachers must learn to negotiate their roles within this community of practice in order to refine their practice (Luehmann, 2007), both that of teaching and reflecting about teaching.

Activity Systems in Activity Theory

Taking into account Vygotsky's, Luria's, Leont'ev's, and other Soviet scholars' works on mediated activity and discourse, Engström refined the socio-cultural-historical perspective of learning and what is now commonly termed *activity theory*, or the cultural-historical-activity-theory (CHAT).CHAT closely follows the ideas of communities of practice and further classifies the elements of those communities. In the second and third generations of the theory, Engström (1987, 1999) defines the following entities of a given community:

- The *subject* is the person or people who engage in the activity.
- The *object* is the goal of the activity. From communities of practice, the object could be called the *joint enterprise*.
- *Mediating artifacts* are the tools used in the activity in pursuit of the object; they can also be environmental elements that shape the activity in a less observable manner. The *shared repertoire* of a community of practice, then, could be considered some of the mediating artifacts.
- The *community* is the group or body whose culture and practices affect the activity; this community could be one constructed in the activity (i.e., consisting of the individuals present) or one in which the activity is situated (e.g., the community of professional teachers).
- *Rules* are practices, habits, and values that structure or influence the activity and are dictated by the community. The *shared repertoire* of a community of practice also includes the community's rules and standards. For the purposes of this discussion, I substitute the term *rules* with the more flexible term *socio-cultural practices*.
- The *division of labor* generally is created by either the subject(s) or by the community and its socio-cultural practices, or by a mixture of both. It can be immediate and obvious, as when a teacher directs a student to read a passage from the text, or more elusive, as with the expectation that the teacher leads the lesson and the students follow.

These elements of an *activity system* and their relationships to one another together lead to an *outcome* of the activity. The traditional triadic representation of such an activity system is presented in Figure 1.

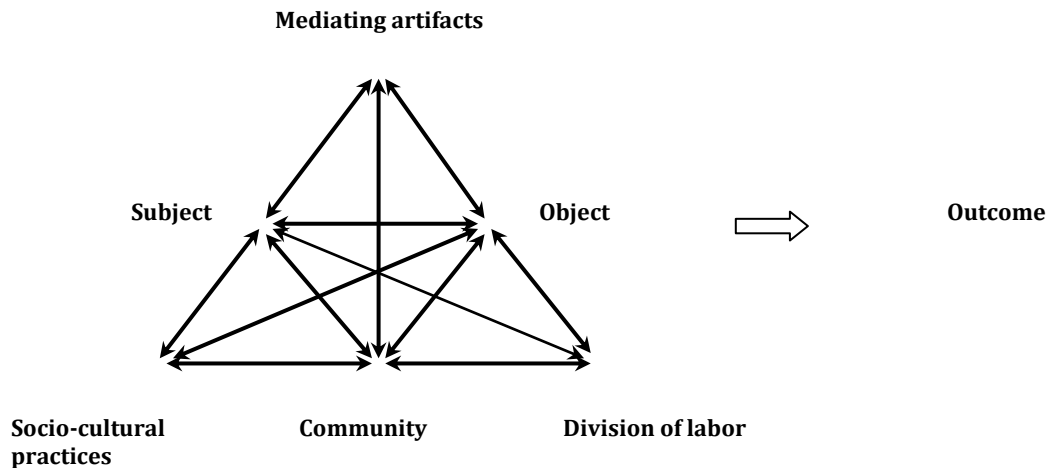


Figure 1. Triadic model of an activity system.

An individual usually is part of multiple activity systems, at times consecutively but sometimes concurrently. Each system is distinguished by the activity that occurs or is attended to; in other words, an activity system is categorized by its *object* or by the *joint enterprise* of the community. A pre-service teacher can, at any one time, be involved in at least three activity systems: the activity of a student, the activity of a teacher, and the activity of a scientist, each with its own object or objects.

Often, pre-service teachers take science classes before classes in education; the teacher's first activity (Figure 2) involves learning scientific practices and building a foundation of content knowledge. Pre-service teachers also take classes in teaching methods in order to learn educational practices and to build a

foundation of pedagogical knowledge. In Figure 3, the pre-service teacher’s activity is that of teaching; this activity is defined by the object, which is often the goal of the lesson (for example, “Student understanding of gravity” or “Experiencing scientific data collection”). Note that the object of the pre-service teacher’s *student* activity system (Figure 4) differs from both the scientific and teaching activities. The other elements of the activity are slightly different, but the object sets the activity apart from the others. In the next chapter, I will discuss how the subject can be defined according to a given activity system, how CHAT relates to identity, and how activity systems can relate to one another.

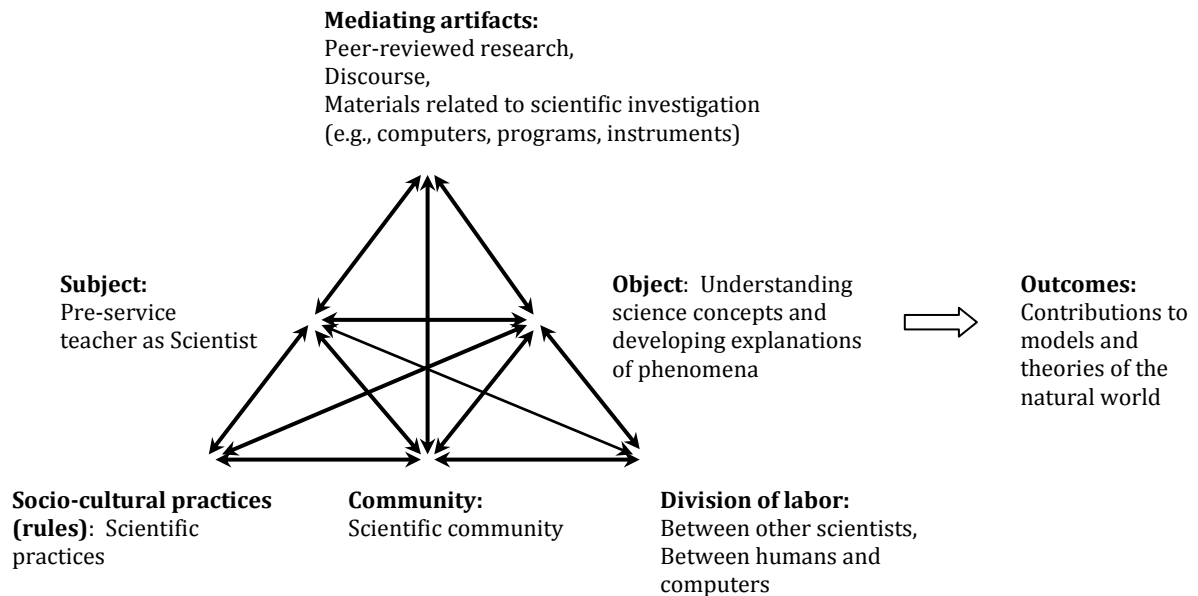


Figure 2. Science activity system of a pre-service teacher.

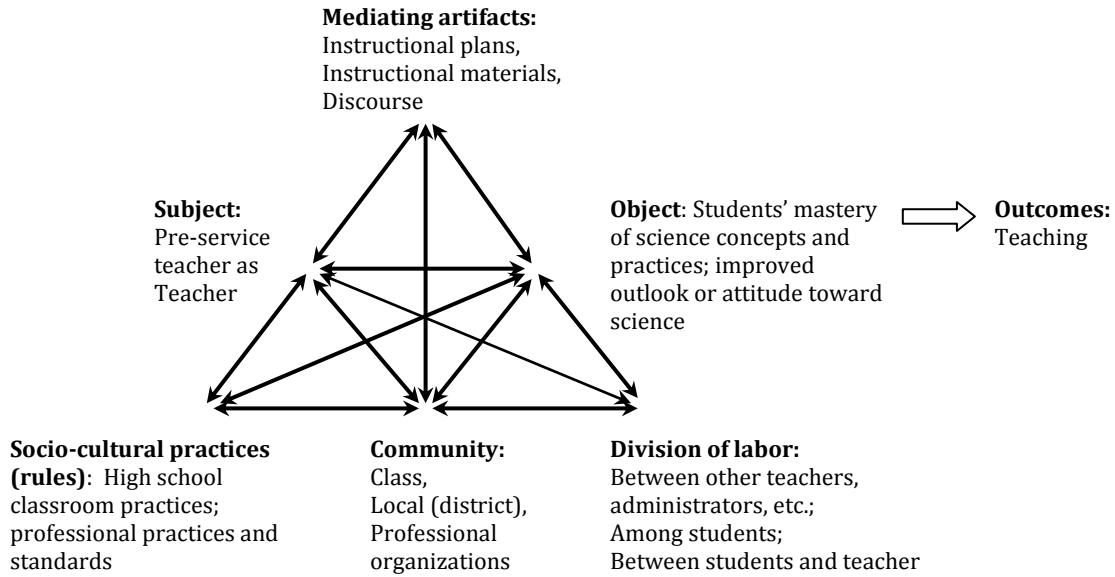


Figure 3. Teaching activity system of a pre-service teacher.

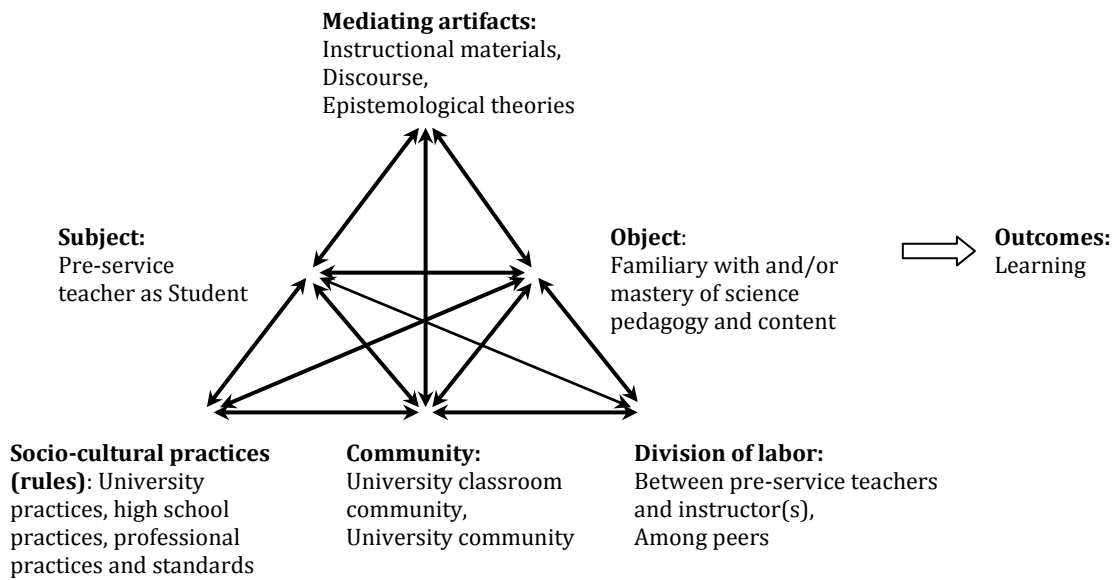


Figure 4. Student activity system of a pre-service teacher.

Chapter 4. Identity

The goal of creating professional vision for teaching is not to create clones of the “perfect teacher.” As Schön and others have argued, teaching is not a prescriptive practice, and there is no “scientific method” of teaching. How, then, do we teach pre-service teachers how to teach? The purposes of reflective practice and of teacher education are not to provide a script to follow; instead, pre-service teachers should use reflection as a means to professional and personal growth. Wenger (1998) argues that learning is a process of identity transformation. In order for pre-service teachers to learn to teach, then, they must transform their identities. But, what is identity? How is it recognized and acknowledged? How can it change or be changed?

Gee (2001) loosely defines *identity* as “the ‘kind of person’ one is recognized as ‘being,’ at a given time and place” (p. 99). Grasping one’s identity can be as tenuous as the definition provided: Personal identity is not concrete and inherent but negotiated by the interactions that take place between individuals and their communities (Gee, 2001; Luehmann, 2007; Sfard & Prusak, 2005; Wenger, 1998). More specifically, and perhaps more importantly, Gee makes distinctions between different types of identities:

- Nature-identity *is* inherent and what one might call *genetic*: “I am a five-foot-two Asian woman.” This identity is not (usually) negotiable.
- Institution-identity is between an individual and an authoritative power: “I am a certified teacher.” My Institution-identity as a teacher is derived from

the fact that I applied for and was awarded a teaching certificate by the State Department of Education.

- Discourse-identity results from and is constantly renegotiated by the relationships and interactions—the *discourses*—between an individual and the community: “People think that I am thoughtful.” Whether or not I am actually a person of depth is not as relevant as the *impression* of my depth; my Discourse-identity is not an observation as much as an interpretation of that observation by myself or others (Sfard & Prusak, 2005, p. 17).
- Affinity-identity is a consequence of practice and is more of action than interpretation: “I teach.” In this case I do not identify as a teacher because of my teaching certificate from the Department of Education; rather, I identify as a teacher because I am continually *engaging in the practice of teaching*.

In each case it is easy to see that identity is, ironically, not personally owned. Instead, it depends on the community and its *shared repertoire* or “way of seeing”—its professional vision. One’s role in the community cannot be “claimed.” In fact, the community and its repertoire assigns an individual’s role in that community, though not without influence from that individual’s actions. Sfard and Prusak (2005) define identity as a *personal story or narration*, such that our identities are defined by interpretations of ourselves. “Stories [identities] are collectively shaped even if individually told, and they can change according to the authors’ and recipients’ perceptions and needs” (Sfard & Prusak, 2005, p. 17). In other words, we author our identities by interpreting our experiences as we understand them, but the

significance and validation of that identity lies in the community's interpretations of our interpretations.

Pre-service science teachers have spent their entire lives thus far acquainted with their Nature-identities—which do not change—and Discourse-identities—which change constantly—in certain communities (for example, in the student community at their university, or in the scientific community). The Institution-identity of being a certified teacher does not guarantee learning to teach. Although a teaching certificate allows the new teacher to practice teaching legally, it does not promise that the teacher will continue learning and improving the practice. In order to learn to teach, new teachers must familiarize themselves with their Discourse-identity and Affinity-identity in the *professional teaching context*. As Wenger (1998) asserts, in order to learn, they must transform their identities: Discourse-identity must be adapted to new discourses—in this case, to the discourses related to teaching and science teaching; Affinity-identity arises as new teachers practice teaching. This identity creation and transformation is how they learn to be teachers.

Another way to interpret identity is through the lens of CHAT. With respect to activity systems, an individual identifies as the *subject* of the activity—the person engaging in the activity in order to reach an *object*. In this regard, identity is defined by the actions or intentions related to an object. Although the subject's role is still defined and negotiated by the community, by its socio-cultural practices, and through its division of labor, this identity is more of *practice* as well as the interactions that take place as a result of or in the midst of that practice. In other words, Gee's Affinity-identity and Discourse-identity resonate most with CHAT, as

they are the two that occur in social contexts. Of course, one should note that the different types of identities are not separate or independent of one another but depend on the circumstances (Gee, 2005, p. 101). In this case, identity depends on the activity.

Teachers must consciously place themselves in the context of their activity, the community, and its socio-cultural practices. They must learn to define themselves by the *objects* of their teaching practice. The practices associated with their teaching Affinity-identities, however, sometimes diverge from the practices with which they are accustomed when their Discourse-identities and Institution-identities from *other* communities prevail. The next chapter looks at the conflicts that occur when identities—and practices—clash.

Chapter 4. Conflict

The new teacher and the non-reflective veteran teacher could easily ignore problems or fail to recognize them. But, with reflective practice, some common conundrums may become evident. New teachers may encounter two types of conflict: Conflicts of identity and conflicts of practice. Sometimes, the two are intertwined, and resolution of these conflicts may involve risk.

Conflicts of Identity

New teachers are still in the process of “finding themselves,” unsure of how they should fulfill their roles in this new community or even what those roles are. Traditionally, identity is thought of as “between the ears,” not negotiated in social interactions. As new teachers struggle in their search for identity, they may fail to consider the bigger picture—to position themselves within a larger community of practice whose bounds are not the classroom walls. This failure to situate oneself in the professional context of the community of practice of teachers, to think within the terms of the community’s socio-cultural practices, and to make connections between the community’s practices and one’s own is often faced by new teachers (Luehmann, 2007). Because learning requires an identity transformation (Wenger, 1998), learning to teach requires the new teacher to align his or her identity with the role required by the community and with the activity of teaching. However, this identity transformation is not without risk (Luehmann, 2007; Mellado, 2006). I will return to the topic of risk later in the discussion.

While enrolled in a teacher education program, pre-service teachers can identify with certain communities of practice: the student community at their university, the teaching community, the scientific community in which they have been immersed during their courses of study, and others (extra-curricular communities, religious communities, and so on). According to Gee (2001), developing Discourse-identity “involves interactions across, and relationships among, different (sometimes aligned, sometimes contesting) social groups, not just intragroup relations” (p. 119); in a similar sense, developing Affinity-identity involves *practices* across and among different—sometimes aligned, sometimes contesting—social groups. The task, then, is to determine which practices are common and which practices are distinctive to certain communities. Generating an understanding of this sense of “belonging” with regards to practice is part of developing one’s identity. When practices cross the boundaries of communities to which they belong, problems can arise; similarly, ignoring practices that are shared by multiple communities can complicate the learning process. For example, constructively criticizing oneself is encouraged in some methodology courses (i.e., having the Affinity-identity of “university student”), but criticizing oneself in front of students in the classroom (i.e., having the Affinity-identity of “classroom teacher”) may cause the new teacher feel a loss of control or authority. Methods exist for constructive criticism of oneself while teaching (that is, reflecting-*in-action*—see Schön, 1983), which should actually improve one’s practice; however, improper execution of self-critique could seem like incompetence. Of course, on the other end of the spectrum, ignoring shared practices among different communities could slow

the process of teaching and learning. Inquiry-based (or reform-based) teaching requires students to behave more as scientists do in constructing meaning from phenomena. Without direct translation from scientific practices to science classroom practices, students may feel lost in this atypical classroom environment. For a more in-depth discussion on inquiry-based and reform-based teaching, refer to the section *Conflicts of Practice*.

Hewson et al. (1999) have found that the current “standard models” of teacher education at the secondary level “are neither oriented towards teaching nor are they particularly relevant to it, and are usually represented in a form that is atomized, static, and with no global vision” (Mellado, 2006, p. 427). In the university classroom, scientific practices are not clearly aligned with teaching practices or vice versa, and thus the commonalities are ignored (as cited in Mellado, 2006, p. 427). Pre-service teachers must learn to distinguish between their identities and practices as students, teachers, and scientists; they also must learn to meld together those identities and practices when appropriate. Growth and development occurs by successfully amalgamating one’s communities in suitable manners rather than by strict categorization of each. Wenger (1998) asserts that identity is a “nexus of multimembership” or reconciliation of one’s memberships in various communities. Mellado argues further that in order for teachers to develop professionally, they must consider and incorporate their personal and social characteristics into their professional identities (p. 428)—in other words, they must view and analyze multiple communities of practice in the process of creating a professional identity.

Conflicts of Practice

Conventional models of teaching, as learned by passive apprenticeship as a student, conflict with models, theories, and practices currently taught in some teacher education programs. These newer models are commonly called *inquiry-based* or *reform-based* teaching, which calls for more a student-centered, collaborative environment in which the teacher no longer acts as leader or lecturer. Students help to define the activity, and the teacher serves as mediator of the activity (McDonald & Kelly, 2007). Mellado (2006) depicts the major problems new teachers face:

... growing interculturality, conflictiveness in the classroom, **the loss of teachers' traditional role of authority**, and the new technologies which give the pupils access to many sources of information and communication, represent a constant challenge to teachers many of whom find a mismatch between what was taught them in their professional education and what is actually expected of them. (p. 420, emphasis added)

Teachers who have not experienced reform-based teaching may dislike that their authority no longer derives from the fact that they are *the* teacher. With more and more classrooms given computers with direct access to the internet, teachers no longer are the single source of information for students, and discussion is no longer restricted to a single block of time in a single room. The teachers' Institution-identity—that is, their title—alone no longer gives them that power. In other words, these teachers' Affinity-identities do not resonate with the practices associated with reform-based teaching because the practices with which they are accustomed

versus the practices they learn in university are so different. Luehmann (2007) argues that teacher education should support the development of a professional identity that is more aligned with reform-based teaching. Rather than having new teachers struggle on their own to develop this identity, this process should be incorporated into teacher education programs through reflective practice (Luehmann, 2007; Mellado, 2006).

Risk

Practices that pre-service teachers learn as students sometimes fail to translate to their practices as teachers, notably if their mentors or administrators do not support reform-based teaching. Because teachers are part of such a large and non-localized community, it may seem difficult for reform to be individually employed (Mellado, 2006).

A study has shown that many science teachers have presupposed notions of scientific practices, for example who a scientist is and what a scientist does (Windschitl, 2004). These “folk theories” of science teaching are embodied in practice and in discourse by institutions that ensure repetition and ritualization of these theories (Windschitl, 2004). In other words, these practices and discourses persist through subconscious behaviors via traditional teaching models. Changing folk theories, or reforming teaching practices, involves risk—learning and employing new practices and transforming one’s identity.

Pre-service teachers who learn about inquiry-based teaching often face a disconnect between theory and practice (Windschitl, 2002; Mellado, 2006;

Luehmann, 2007) from the university classroom to the high school classroom, sometimes because of folk theories embedded in their experiential knowledge. Accepting new pedagogies and new socio-cultural practices means developing a new professional identity, in which Luehmann (2007) includes “professional philosophy, passions, commitments, ways of acting and interacting, values, and morals” (p. 828). However, acknowledging that pedagogies and practices need to be changed means conceding that one’s teaching practices could be improved; this entails confidence and self-esteem (as cited in Mellado, 2006, pp. 428-429). In order to develop a professional identity as a reform-based teacher, alternative practices must be presented that are better suited to the activity of teaching and learning science (Mellado, 2006, p. 425), and teachers must re-negotiate their Affinity-identities to align their teaching practices with reform-based teaching, which melds together the “Student,” “Teacher,” and “Scientist” identities of a pre-service teacher. By bringing theoretical concepts and pedagogies from the university classroom as well as scientific practices into the high school classroom, teachers can conduct their activities with higher awareness of practices common to the three different communities of practice. Teachers need the support and cooperation of other members of the community of practice—whether students in the classroom, administrators in the school, or other teachers in the professional community—so that *all* members of the community may align their activity to the object at hand (Luehmann, 2007; Windschitl, 2002).

Reflective practice may assist in professional identity development by focusing the teacher’s attentions to problems in current teaching practices as well as

personal, social, and professional conflicts as they relate to their respective communities of practice. Although aligning one's practices with a given community of practice may help resolve some conflicts, bringing together multiple communities may actually improve practice. Finding common practices not as an individual in one community but as a member of multiple communities may broaden a teacher's perspective on the activity. Reforming the practice of teaching and establishing a professional identity as a reform-based teacher does not involve *substituting* certain activities with others; rather, growth and development—change—of one's practices and identity leads to reform (Mellado, 2006). Tobin (1998) declares: "Indeed, the co-existence of apparently divergent schools of thought, far from being a weakness of development, may rather be the natural state and a reflection of maturity, allowing one to better understand the multiple nuances in the complexity of teaching" (as cited in Mellado, 2006, p. 439). The expert teacher is a lifelong student, formal or informal, who learns to improve his or her practice through *transforming* his or her identity into that of a reform-based teacher (Wenger, 1998), relating practices from various communities, and with conscious awareness of the objects of his or her teaching.

PART TWO

THE STUDY

Chapter 5. Setting and Design

As part of the requirements of the science education program at the Pennsylvania State University, pre-service teachers must take a science teaching methodology class (SCI ED 411). Throughout the class, the pre-service teachers familiarize themselves with the Pennsylvania Department of Education's Science & Technology standards, train themselves to use technology (such as PASCO equipment and DataStudio) in their lessons, and learn to incorporate inquiry-based science teaching and learning in their lessons. For one of their assignments, the pre-service teachers, in pairs, develop a lesson of approximately twenty minutes to be taught to small groups of three to five middle school students in a "teaching clinic." The lesson must address at least one of the Standards, use technology, and involve some form of scientific data collection. The content and goals of the lesson are at the discretion of the teaching pair, but the course instructor evaluates the lesson plan and suggests modifications. In preparation for the clinic, each pair practices teaching the lesson to their classmates, who also suggest modifications.

For this study, fifth and sixth grade students came from a local charter school. Students' parents signed permission slips allowing their children to be videotaped during the event. Students whose parents did not return the permission slip participated in the teaching clinic but were not videotaped. The students' regular classroom teachers pre-assigned groups of three to five children, and each group attended a total of three lessons taught by different teaching pairs. Of twenty-three pre-service teachers in this study, ten lessons were taught by pairs and one

lesson was taught by a group of three. The students' regular classroom teachers did not take active roles during the lessons.

At the conclusion of the teaching clinics, each pre-service teacher viewed the video recording of his or her lesson and was instructed to select a continuous five-minute segment of that video to make observations; partners did not have to use the same video segment. Each pre-service teacher recorded his or her reflection as an audio track over the chosen video segment. The pre-service teachers also were required to submit a written reflection of their experience in the teaching clinic, which could be completed individually or as a pair and did not have to correlate with the video recording. Pre-service teachers were not given prompts for either the audio or written reflections.

Chapter 6. Analytic Approach

The data for this study include the teaching pairs' lesson plans, video for each of the 11 lessons, 23 voice-over (audio) reflections, and 13 written reflections.

Working with the original research team (see Sezen et al., 2009), I transcribed the lesson videos as well as the voice-over reflections using Studiocode®¹. The video and transcript of each lesson were used to create an event map, which depicts the phases and sequences of the lesson (Kelly & Chen, 1999; Brown & Spang, 2008) and shows to which segment of the lesson each pre-service teacher attended. The voice-over reflection transcripts and written reflections were broken into lines of talk (or, in the case of the written reflections, sentences) and coded under three separate frameworks. Initially, an inductive, category-generating process yielded Subject of Observation codes and Topic of Observation codes; secondly, the CHAT framework yielded codes according to Engström's model of an activity system (see Chapter 2); and finally, the reflections were coded under an identity framework (see Chapter 3).

We began coding by looking for major, repeating focal points of observation and found that the pre-service teachers often mentioned individuals in their reflections—for example, the fifth and sixth grade students or themselves. This was coded under "Subject of Observation," referring to the person(s) who is the focus of the statement. The "self" category was coded when the pre-service teacher made an observation about himself or his partner, and the "student" category was coded

¹ Video analysis software. For more information, go to <http://www.studiocodegroup.com>.

when the pre-service teacher made an observation about the fifth and sixth graders. The “self” category then was broken into sub-categories, such as “author to himself,” “collective (e.g., “we”), or “other teacher”; similarly, the “student” category was broken into the sub-categories “individual” (one student), “collective” (all students), “specific group” (e.g., “all the girls”) and “group of individuals.” The last sub-category is more generalized and does not fit under any of the others, as when the author states, “some of the students thought....” The other general category we found in the inductive coding process was “topic of observation.” This broader category includes references to the science of the lesson, teacher and student actions, and teachers’ and students’ learning processes. For an example of these coding procedures, see Appendix C.

We created a reference table for the categories, sub-categories, typical examples, and references to the speaker/author (i.e., the pre-service teacher) and line number in the voice-over transcript for each the subject of observation categories (Table 1) and topic of observation categories (Table 2). Although written reflections were coded, they were not used to create the reference tables. Following the inductive coding process, we created a frequency table to provide an overview of the variety and recurrence of the pre-service teachers’ observational focus.

Subject of observation category		Typical example	Index	Comments
Self-referential	author to herself	"...I wrote the word polarization on the board,..."	AM-08	This refers to a subset of the collective group of students that is not a specific group. The students' regular classroom teacher.
	collective (we)	"We're asking them what exactly is they, they see..."	AM-09	
	other teacher	"...Adam is making sure that they understood that all light intensity went down..."	YA-15	
Students	individual	"...one of the students completely hit the nail in the head,..."	AM-29	
		"...the girl in the far back is testing that with polarizing sheet,..."	YA-26	
	specific group	"...my group had noticed that it went down by half."	YA-16	
	collective (they)	"...so they [students] saw the effects of the polarizing sheets on light intensity."	YA-03	
	group of individuals	"...that might've actually lost some kids"	CY-20	
Other	collective (we) - entire class	"we'll go through and we'll observe the results"	SU-30	
	other	"the teacher's staring at..."	EN-06	

Table 1. Reference table for inductive subject of observation codes.

Topic of observation category		Typical example	Index
Science	concepts	"the thing with polarization"	AM-18
	physical processes	"polarizing sheets can block light"	YA-02
	practices	"we're just having them, uh, observe [this phenomenon]"	AM-05
	equipment	"we had a tube with...two polarizing sheets"	AM-07
Observations about students as learners (SAL)	knowledge level	"this concept is a little bit above the fifth grade level"	AM-13
	learning process	"They, definitely were strong in brain storming"	AM-16
	being engaged	"they feel less excluded"	CB-21
	maturity/emotional level	"more conducive to, kindergarteners maybe"	CB-03
Observations about teachers as learners (TAL)	changing practices	"I'll definitely have to adjust that"	CB-09
	moving	"I liked...that, I went to one side of the table"	HY-29
	speaking	"my, voice, is decent at times"	CB-03
	using tools	"shoulda used that, dry erase board"	CB-07
Student actions	asking questions	"...one kid asked if polarizing meant just water..."	YA-31
	drawing/inscribing	"[they] got to...draw the cells"	IA-11
	making guesses	"they were thinking of different ways they could do it"	YA-06
	responding	"they didn't really seem to respond too much to me"	IA-22
		"all four of them were responding to the questions"	RA-12
Teacher actions	asking questions	"we're asking them for guesses"	AM-12
	assigning tasks	"We gave them...a task to do on their own"	YA-05
	guiding/leading	"We didn't really lead them in any direction"	YA-11
	making analogies	"you think flex, 'cause they rhyme together, and when you flex your muscles they come out"	CY-05

Table 2. Example of reference table for inductive topic of observation codes.

We then applied the CHAT framework to code the voice-over transcripts, with categories following the traditional triadic model of an activity system: “subject,” “object,” “socio-cultural practices,” “community,” “division of labor,” “mediating artifacts,” and “outcome” (Engström, 1999), followed by sub-categories (e.g., mediating artifacts: instructional plan, instructional materials, discourse). The pre-service teacher pairs’ lesson plans provided the intended objects of the activity.

CHAT Code		Typical example	Index
Subject	Student (5th and 6th graders)	"non-English, learners, and also for the sixth graders themselves"	CY-08
	Pre-service teacher	"I would glance at [the name tags] and not be able to read them quickly enough"	CB-14
Mediating artifact	Discourse	"describing mechanical advantage to the other students"	EN-18
	Instructional materials	"questions that we had written out for them, on a worksheet"	EA-10
	Instructional plan	"a lesson on microscopes"	RH-01
	Previous knowledge	"I want to establish prior knowledge"	RH-02
Socio-cultural rules (practices)	Educational practice	"I explained to them"	SA-06
	Scientific practice	"to compare the densities of..."	RL-01
Community		"the gender split between the two groups"	CY-19
Division of labor	Among students	"each student's gonna get to move the cart"	SU-30
	Between pre-service teachers	"we have to split up and start working with different people"	EN-16
	Between pre-service teachers & students	"we had them put temperature probes"	EA-02
	Between humans and computers	"if you draw the cart back, it will draw a graph on the computer"	SU-29
Object		"we were hoping they could apply the same thing; we just wanted to see if they actually took that out of the lesson"	YA-25
Outcome		"...this was beneficial to them"	HY-33

Table 3. Reference table for CHAT codes adapted from Sezen et al., 2009, p. 22.

While coding in conjunction with the original research team for the National Association of Research in Science Teaching (NARST) 2009 conference, I noticed that the pre-service teachers rarely spoke of themselves as part of the classroom community (this appears as the “other—entire class” code), and that for the most part the pre-service teachers seemed to separate themselves from the students in traditional teacher-leader/student-follower roles. This seemed incongruent with the student-centered teaching approach that is presented in the SCI ED 411 class and in my experiences in the teacher education program. Individually, and finding inspiration for this thesis, I re-coded the voice-over transcripts and written reflections under what I now call the “identity” framework. The self-referential subjects of observation from the original inductive, category-generating codes (Sezen et al., 2009) were parsed into slightly different “identity categories,” this time focusing only on the pre-service teacher’s references to himself or herself; this disregards mentions of the other pre-service teacher (partner) in the activity as well as the fifth and sixth graders.

Drawing from personal experience, I deduced that pre-service science teachers can adopt practices from at least three different communities that directly affect the outcome of this activity: the scientific community, the student community, and the teaching community. The “scientist” category was coded in the reflections when the author attended to specific scientific practices or commented on his behavior as a scientist. For example, in Cathy’s voice-over reflection, she noted that her students believed light rays would pass through convex and concave lenses in exactly the same manner; as a scientist, those notions “to me seemed

counterintuitive” (line 26). A teacher has no reason to believe one way or another about the behavior of light rays; nor does a student. (Of course, this is generally speaking of students, as students in disciplines other than physics also would have no reason to believe one way or another about the behavior of light rays.)

The “student” category was coded when the pre-service teacher referred to himself as a student, for example completing the assignment for the class, evaluating his performance, or mentioning methods of improving his practice. Keenan’s voice-over reflection begins: “Okay, first, it was difficult finding a full five-minute section. The first part, I was out of frame, and the second part, Ryan was talking most of the time” (lines 2-3). Although an expert teacher collects data and reflects on the evidence to further his practice, Keenan’s statement is a specific reference to the post-clinic assignment using lesson videos from the clinic; in this reflective activity, from this comment, he is a student.

The “teacher” category was coded when the pre-service teacher indicated a teaching practice *without* making an evaluation. For example, Emma stated in her voice-over reflection: “...we helped the students to make sure, that they were recording their temperature in the right spot on the table, that we had given them” (line 6). She observed her action as the teacher—guiding students to fill in a table—without suggesting that this action is “good” or “bad”; her statement is neutral to that effect. As a check, substituting “I, *the teacher*, lectured about...” or “I, *the student*, learned from this experience...” helped to clarify some of the codes. There were instances, however, of ambiguity—for example, “Teacher/Class” was coded when the speaker/author could refer to “we the teachers” or “we the entire class.” Table

4provides the categories, typical examples, and references for these identity categories. A frequency table was created for the identity-related codes. For an example of the identity-related coding process, see Appendix J.

Identity category	Typical example	Index
Scientist	"[light rays passing through through concave and convex lenses the same way] just to me seemed counterintuitive"	CY-26
Class/Scientist	"[we are going to be real scientists, and,] we are going to make predictions"	KA-04
Student	"the first thing I want to mention about this [video] is..."	RN-02
Student/Teacher	"it was our first time teaching students"	CRY-36
Teacher	"I'm just lecturing"	RH-20
Teacher/Class	"we could've been discussing the preliminary questions"	RA-12
Class	"We have the number of just the beaker and we have the number with..."	RTA-14
Ambiguous	"I've been TA-ing..."	RN-27

Table 4. Reference table for identity-related codes.

Naturally, in the process of evaluating their performance in the teaching clinic, some pre-service teachers mentioned problems they experienced. These conflicts were noted and recorded but not explicitly coded as with the previous three coding procedures.

Chapter 7. Findings

Of a total of 1392 identity codes in pre-service teachers' voice-over and written reflections after the micro-teaching activity, pre-service teachers most often identified themselves as teachers (63% of codes). The inductively generated categories showed a more subtle continuation of that trend. Of those codes, 27% fell under "Teacher actions," the second-most frequent category after Science (29%). The "Teacher actions" code points to the pre-service teacher's identification of himself or herself as the teacher performing typical—that is, traditional—teaching practices, for example asking questions or assigning tasks. Although these individuals have not yet graduated, it is interesting to note that they have already adopted full membership in the professional teaching community.

Pre-service teachers identified themselves as students in 18% of the identity-related codes, the second-most frequent identification in that framework. 11% of the inductively generated codes fell under "Teachers as learners," which implies that the pre-service teacher is evaluating himself or herself and sometimes is offering suggestions for improvement. With respect to the framework presented in Part 1, this indicates that the teacher considers himself or herself a student in the instances where this was coded. These data correlate with the identity codes, in which the teachers identified themselves as teachers more often than as students. Again, although these individuals have not yet graduated, it seems that they do not include themselves in the student community of practice as much as the teaching community of practice.

In only 6.8% of the identity codes, pre-service teachers identified themselves as part of the classroom community, and they identified themselves as scientists in less than 1% of the codes. As pre-service science teachers, these individuals have spent many years incorporating scientific practices into their everyday repertoire, but they appear not to explicitly or consciously adopt membership in the scientific community during the course of this micro-teaching event. Granted, the focus (that is, object) of this activity in the teaching clinic is to practice teaching and conduct self-evaluation and not necessarily to comport oneself as a hard scientist; however, in light of the model of reform-based teaching, it would be interesting to observe how the outcomes of this activity could change if the pre-service teachers more deliberately adopted common practices from multiple communities (teacher, student, *and* scientist) rather than maintained emphasis on just one (in this case, teaching). Because pre-service teachers separated themselves from the fifth and sixth grade students in most cases rather than incorporating themselves into the classroom community, it would seem that these teachers, for the most part, did not fully espouse reform-based teaching, which de-emphasizes the teacher's role as the one authority or power. A community-based model of teaching was not readily apparent in the voice-over or written reflections.

Of all self-referential subjects, 88% of the identity-related codes were, for the most part, plainly categorized (see Table 4 for examples of clearly defined codes). The remaining 12% of the total codes were ambiguous in nature. Pre-service teachers waivered between students and teachers ("student/teacher" code) 5.4% of the time, between teacher and the classroom community 5.4% of time, and sharing

the role of scientist with the class less than 1% of the time. These ambiguous codes seem to show multimemberships in communities of practice, where the pre-service teacher is on the periphery (Wenger, 1998) of multiple communities. However, this reflection of multimembership only occurred in 12% of all the codes; in the rest of the instances, according to the coding methodology, the pre-service teacher clearly aligns himself or herself with a single community of practice: namely, the community of practice of teachers.

With regards to the CHAT framework, pre-service teachers attended to scientific practices 7.6% of the time and educational practices 11% of the time. The educational practices that were coded tended to echo the “teacher actions” codes in the inductively generated categories: that is, the pre-service teacher mentioned an action that is typical of a professional teacher or an interaction that is typical of a traditional classroom (for example, explaining an idea or waiting for a student’s response). The difference in frequency between mentioning of scientific practices and educational practices is not statistically significant but does show that teachers more often attended to the socio-cultural practices of the teaching community than of the scientific community. Pre-service teachers only mentioned community less than 1% of the time, showing that they do not consciously or explicitly attend to the idea of community (or communities of practice) when reflecting upon the activity.

Beyond the codes, the pre-service teachers sometimes mentioned conflicts that occurred during the activity. Notably, these conflicts dealt mostly with practice. Some of the conflicts resulted from differences in classroom expectations; for example, when students did not participate openly or seemed to not pay attention,

pre-service teachers viewed this as a a problem that needed to be fixed. In these cases, the students' behaviors did not match the pre-service teacher's ideas of educational practices. One pre-service teacher, Cathy, mentioned "the isolation, like the gender split" between the boys and girls in her group; this conflict was in creating a single classroom community. Another pre-service teacher, Caleb, expressed regret that he did not address his students by name:

Knowing names, is very important. I came to realize watching this [video]....I was too proud or something, to ask them what their name tag says. As though asking them would advertise I made some sort of mistake. But, actually, you know, asking them for their name, and going about as I did [not asking their names] is, more of a mistake. (lines 8-12)

By not addressing his students by name, it seems Caleb felt that he prevented a more personal connection between himself and his students, or that he possibly prevented further discourse by ostensibly alienating his students.

Some pre-service teachers mentioned conflict in implementing reform-based or inquiry-based teaching. Several pre-service teachers noticed that students were not able to construct their own meanings from phenomena: when students did not know the answer to a particular question, they did not venture any guesses, and the pre-service teachers in turn "ended up just telling them [the answers]" (Matt, line 11). Similarly, Cathy asserts in her reflection: "...kids don't know the answer to the question but they know whatyou're looking for, and so they fill in the blanks until they hit the right one, and there's very little actual understanding going on behind it" (line 30). Both Matt's and Cathy's statements, along with other pre-service

teachers' reflections, note that the young students often were hesitant or unable to create their own meanings, a key concept in inquiry-based teaching. Possibly the students did not have prior experiences in reform-based classrooms and therefore could not meet the pre-service teachers' expectations in this new environment.

India reflected that the time used for "lecture" took away from the "actual inquiry part of the lesson"—although the teaching pair planned to utilize inquiry, lack of adequate time prevented it. Ruth, her partner, regretted that there were not enough microscopes for each student to follow along during the demonstration of the equipment, making that portion of the lesson "not very interactive." Lennie stated that, although he realized that each group was to practice inquiry-based teaching in the clinic, his group's lesson was "not quite inquiry in its purest form." In each case, the pre-service teachers' expectations as *students* did not match their performances as *teachers*. Their *student* object of practicing inquiry did not equate with their *teaching* objects of content delivery, revealing an apparent divergence between these two activity systems.

There were no evident conflicts dealing with the pre-service teachers' scientific activities, although there were some instances where students, as expected, did not understand certain scientific procedures. For example, Lennie observed that the students were concerned with a temperature fluctuation of a few tenths of a degree, not realizing that this variation was not scientifically significant and actually was an indication of the temperature probe's limitations. In this case it may have been prudent to introduce to the students some practices from the scientific community, such as owing this fluctuation to the equipment's sensitivity

rather than to the scientific processes involved. This is an instance where a pre-service teacher could make scientific practices common to his regular classroom practices to further the students' understanding by allowing them to focus on more significant matters.

The pre-service teachers' conflicts, when noted, dealt with problems of practice. The teachers were not aware of or did not attend to conflicts of identity, at least not explicitly. As seen in Chapter 4, conflicts of identity and practice are often interrelated in that identity often reflects practice, and practice is based on identity. The pre-service teachers seemed confident and grounded in one community of practice—the activity of teaching—and not as engaged in the activities of students or of scientists. Most did not reflect on their experiences in an evaluative manner or reflect-*for*-action (Thompson & Thompson, 2008), although some did suggest areas of improvement.

Chapter 8. Conclusions

Again, it should be noted that these pre-service teachers' reflections were not evaluated on the basis of quality or amount of reflecting *in, on, or for* action (Schön, 1983; Thompson & Thompson, 2008). It is refreshing to see that, though not prompted to do so, some pre-service teachers did offer suggestions for improving their practice as teachers, and as such they still engage in the practices of students—that is, they still engage in learning from their experiences.

How can identity awareness inform teacher education? Currently, no requirements exist for pre-service teachers' exposure to the concepts of community of practice or activity theory, and exposure to these ideas is not guaranteed. These pre-service teachers often operate without "open" or explicit knowledge (Thompson & Thompson, 2008) of reform-based teaching practices, instead relying on practices subconsciously learned through the traditional apprenticeship model. Educational goals or objectives usually are included in lesson plans, but pre-service teachers should develop their *objects* in the context of the activity, with knowledge of the mediating artifacts or tools to be used, and with awareness of the socio-cultural practices embedded in their communities. For the most part, in this study, it was found that the pre-service teachers mostly align themselves with the community of practice of traditional teachers and less so with the communities of practice of students, scientists, and reform-based teachers. Their identities and practices—scientific, student, and teacher-related—as revealed in their reflections, were separate rather than integrated. In becoming a reform-based teacher, pre-service

teachers must develop a concrete sense of their identities through reflective practice that reconciles their memberships in multiple communities of practice. To incorporate practices from various arenas of activity may allow pre-service teachers to concern themselves less with conflicts such as a student's apparent lack of attention and instead to consider alternate practices in which the problem could be re-framed as an adaptable activity-oriented obstacle. Perhaps the student is not bored or lazy but rather without clear foresight into the joint enterprise in which he and his community are engaged. Tobin's (1998) suggestion that the "co-existence of apparently divergent schools of thought...may rather be the natural state and a reflection of maturity" (as cited in Mellado, 2006, p. 439) resonates with this idea of transforming one's identity to accept multimemberships in communities of practice—scientist, student, and teacher—and assimilating their practices into one of reform-based teaching.

I propose that the following should be considered for teacher education programs:

1. Pre-service teachers should be exposed to reform-based or inquiry-based teaching in their courses of study. This means that pre-service teachers must be made aware of hidden biases and flaws in traditional teaching models and benefits of reform-based teaching. Learning about reform-based teaching goes beyond learning the practices: It includes re-shaping one's ideas about the traditional classroom to design a community that includes teachers and students as active agents—subjects—in joint

enterprise, one that extends beyond the physical boundaries of the classroom.

2. Pre-service teachers must be given ample opportunities to practice reform-based teaching. These opportunities should be made available before graduation, while the pre-service teachers have guidance and before they are left to fend for themselves. In student teaching field experiences, pre-service teachers should be matched with mentors who also practice reform-based teaching so that they have equivalent and not competing goals.
3. Pre-service teachers must reflect actively and often in the course of practicing reform-based teaching in order to shape their identities as reform-based teachers. This new identity unites the communities of students, teachers, and scientists and their practices into a new community of reform-based teachers and learners. With the guidance of their mentors and course instructors, pre-service teachers may learn to reflect-*in-action* to recognize and resolve conflicts in this new context.

I offer a new activity system of reform-based teaching in Figure 5.

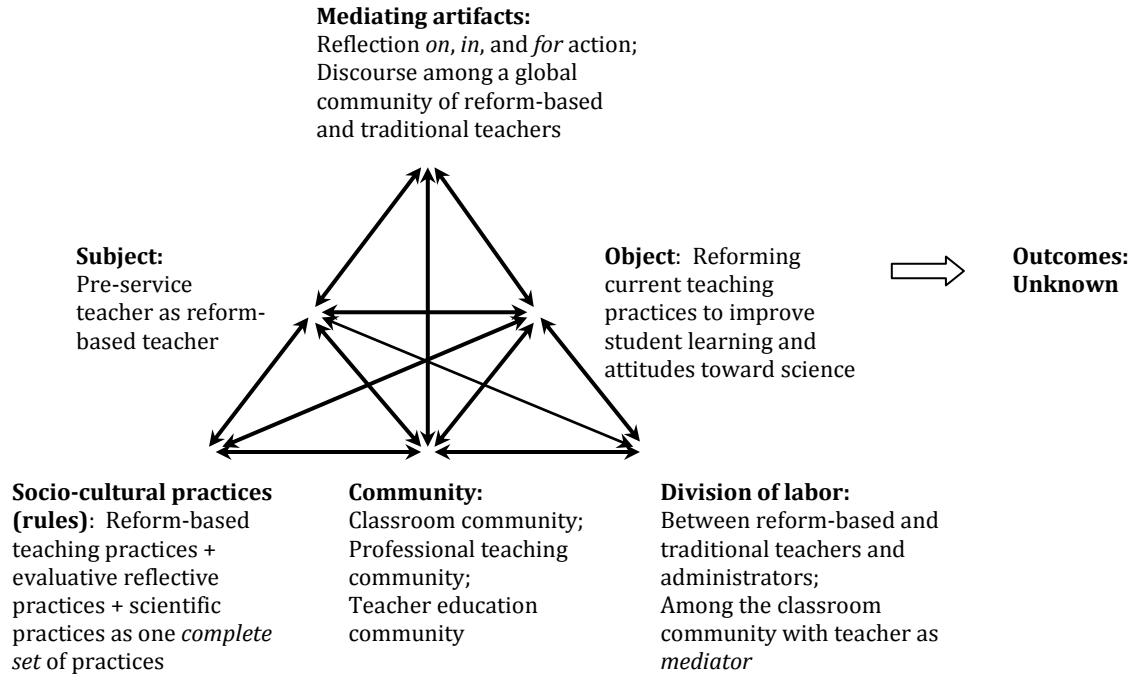


Figure 5. Proposed activity system of reform-based teaching.

With this new system at the forefront of each pre-service teacher’s activity, we may begin to reform the practice of teaching into something that is more relevant and more effective than current models. This is not to say that in-service teachers cannot be part of the reform; reflection to transform identity should play a part in all teachers’ practices. Rather, giving pre-service teachers such a framework for community-building and reflection from the beginning may ease their transition into the professional community of teachers, hopefully one with reform in mind.

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Appendix A. Example transcript of micro-teaching event

Speaker	Line	Talk	Actions
Adam	2.1	Um, there's a lot of weird properties of light, but one of the best ways to treat light is like a wave. Just like a water wave? Except, a water wave goes up and down like you can just see it going up and down in one direction, right?	Adam moves his left hand horizontally, making crests and troughs in a water wave-like motion.
Yolanda	2.2	And light, travels in two directions. It goes perpendicular.	Yolanda places her right hand above her left hand with palms facing each other; she undulates both hands toward and away from each other (up and down).
Adam	2.3	Up and down.	Adam mimics Yolanda's hand motions and takes a step closer to her.
Yolanda	2.4	Up and down and left and right.	
Adam	2.5	So it's kind of like this, you have like waves going in all directions.	Adam stands behind Yolanda with his arms around her. His left and right hands, palms facing each other, undulate in and out (left and right).
	2.6	You guys kinda understand what we're trying to illustrate?	
Kevin	2.7	Yeah.	
Yolanda	2.8	So we'll draw that on the board.	Adam steps to the whiteboard and picks up a marker.
	2.9	So if we're just looking in the up and down direction, light will go, in all these ways.	Adam makes a dot on the board. He draws arrows outward from the dot: one up, one down, one left, and one right.
	2.10	Now what these sheets do, it's called polarizing, is, it'll only let light that is polarized in that way. So, light that is in that direction.	Adam begins to draw a box down and to the right of the arrows.
	2.11	So if you put a sheet right here, and all lines in the sheet are polarized up and down? The only thing that lets through there is the up and down waves.	Adam draws up arrows next to the box. He draws a line extending from the upper left of the dot, through the dot, and then through the box.
Adam	2.12	So it gets rid of the waves that are traveling in the left and right direction.	Adam draws a dot with an up arrow and a down arrow extending out of the dot to the lower right of the box.
Yolanda	2.13	It's only going like that.	Yolanda repeats her hand-undulating motion.
Adam	2.14	So if we have light that's going like this and it goes through the up and down polarizing sheet, the left and right goes away.	Adam steps behind Yolanda and repeats their wave-undulating motion. He flares his arms outward and steps away from Yolanda.
	2.15	So you, you're blocking out part of the light, the part of the light that's going in the wave direction left and right.	Adam makes some hand gestures, then makes his left-and-right undulating motion.

Appendix B. Example event map of micro-teaching event

Phase			Sequence		
#	Time	Description	#	Time	Description
2	01:59 - 04:50	Engaging students; Introducing polarizing sheets	1	1:59	Teachers introduce and demonstrate polarizing sheets. Adam holds two sheets up and rotates the back one, which causes the light going through the sheets to be blocked.
			2	2:46	Teachers show students a "polarizing tube" and allow them to manipulate it. Yolanda asks for the students' observations.
			3	3:49	Teachers ask the students for guesses about what is happening with the polarizing tube and sheets. Students wonder if there is something inside the tube that's causing it to block the light. One student guesses that the polarizing sheets have the same behaviors as transition lenses.
3	04:50 - 08:34	Providing explanation; Evaluating students	4	4:50	Teachers ask students what they think the nature of light is (particle, fluid, gas), and then the teachers explain the nature of light as a wave and that it travels. Teachers make an analogy to water waves. Adam draws an arrow representation of light ("up and down and left and right") and explain how polarizing sheets block "up and down" or "left and right" parts of light.
			5	6:32	Teachers ask students why the second polarizing sheet causes all light to be blocked. One student answers that turning a second polarizing sheet so its orientation is different than the first's will block all the light. Adam then draws the arrow representation of what the student describes.
4	08:34 - 10:56	Setting up/ Preparing for prescribed experiment	1	8:34	Teachers describe the experiment to the students. They explain how to read the graph and use the computer program. They give a demonstration of the experiment but have some computer trouble, which Adam fixes.
			2	10:29	Teachers demonstrate the experiment again.

Adam's voice-over: 01:58 - 06:58

Appendix C. Example of voice-over transcript coded inductively

ADAM (AM)		Subject-Related Codes		Science- and Action-Related Codes	
Line #	Transcription	Codes	Code References	Codes	Code References
7	We had a tube with, two polarizing sheets that Yolanda's holding right now, and she's about to hand them to the students so that they can have a look and, control the phenomenon on their own, and make some guesses as to what is actually going on, with this phenomenon.	Self - Collective	We had	Science - Equipment	tube; polarizing sheets
		Self - Other teacher	Yolanda's holding; she's about to	Science - Practices	control the phenomenon
		Students - Collective	the students; they can have; on their own	Student actions - Making guesses	make some guesses
				Student actions - Making observations	they can have a look
8	We had, I, I wrote the word polarization on the board, just kinda to introduce the terminology, but right now we're just trying to, have them explore this, phenomenon, and see, what's going on.	Author to himself	I wrote	Science - Inscriptions	the word polarization [written]
		Self - Collective	we're just trying	Science - Concepts	the terminology ["polarization"]
		Students - Collective	have them explore this	Science - Practices	explore this phenomenon
				Science - Physical processes	phenomenon [of polarization]
				Teacher actions - Drawing/Inscribing	wrote the word polarization
				Teacher actions - Introducing concepts	to introduce the terminology
				Teacher actions - Assigning tasks	have them explore...and see
				Student actions - Making observations	have them explore this; see...what's going on

Appendix D. Summary of inductive codes regarding subjects

Subject of observation		Total frequency	Percentage of total subject codes
Self-referential	author to herself/himself	208	12
	collective (we)	541	31
	other teacher	38	2.2
	Section subtotal	787	45
Students	individual	92	5.3
	specific group	107	6.2
	collective (they)	591	34
	group of individuals	64	3.7
	Section subtotal	854	49
Other	collective (we) - entire class	76	4.4
	other	15	<1
	Section subtotal	91	5.3
Total subject of observation codes		1732	

Appendix E. Summary of inductive codes regarding science

Topic of observation		Total frequency	Percentage of total topic codes
Science	concepts	327	10
	physical processes	176	5.4
	practices	150	4.6
	equipment	150	4.6
	inscriptions (e.g., graphs)	122	3.8
	Section subtotal	925	29

Appendix F. Summary of inductive codes regarding students

Topic of observation		Total frequency	Percentage of total topic codes
Observations about students as learners (SAL)	knowledge level	121	3.7
	learning process	237	7.3
	positing knowledge to student(s)	50	1.5
	being engaged	140	4.3
	maturity/emotional level	26	<1
	Section subtotal	574	17
Student actions	asking questions	14	<1
	discussing	52	1.6
	doing experiments	86	2.7
	drawing/inscribing	21	<1
	making analogies	3	<1
	making guesses	115	3.6
	making observations	92	2.8
	responding	66	2.0
	testing ideas	32	1.0
	Section subtotal	481	15

Appendix G. Summary of inductive codes regarding pre-service teachers

Topic of observation		Total frequency	Percentage of total topic codes
Observations about teachers as learners (TAL)	evaluating activities	96	3.0
	evaluating self	31	1.0
	speaking	13	<1
	using body language	7	<1
	changing practices	103	3.2
	using tools	54	1.7
	making errors	32	1.0
	maturity/emotional level	23	<1
	moving	12	<1
	Section subtotal	371	11
Teacher actions	aligning	167	5.2
	asking questions	123	3.8
	assigning tasks	99	3.1
	demonstrating	49	1.5
	describing/explaining	111	3.4
	drawing/inscribing	16	<1
	evaluating students	70	2.2
	giving examples	14	<1
	guiding/leading	79	2.4
	introducing concepts	19	<1
	making analogies	7	<1
	supervising	64	2.0
	using tools	64	2.0
	Section subtotal	881	27
Total topic of observation codes		3232	

Appendix H. Example of voice-over transcript coded with CHAT framework

ADAM (AM)		CHAT Codes		
Line #	Transcription	Codes	Code References	Comments
7	We had a tube with, uh, two polarizing sheets that Yolanda's holding right now, uh and she's about to hand them to the students so that they can have a look and, uh control the phenomenon on their own, and uh, make some guesses as to what is actually going on, uh, with this phenomenon.	Mediating artifacts - Instructional materials	tube with...polarizing sheets	
		Division of labor - Between pre-service teachers	Yolanda's holding; she's about to hand them to...	One teacher is manipulating (holding) the instructional materials.
		Division of labor - Between pre-service teachers & students	they can have a look; control the phenomenon on their own; make some guesses	Teachers hand off the labor in this portion to the students.
		Socio-cultural practices - scientific practice	have a look; make some guesses	scientific practice
8	Uh, we had, I, I wrote the word polarization on the board, just kinda to introduce the terminology, but right now we're just trying to, have them explore this, uh, phenomenon, and see, uh, what's going on.	Mediating artifacts - Instructional plan	introduce the terminology	This is directly from the lesson plan.
		Division of labor - Between pre-service teachers	I wrote the word polarization	Not both teachers.
		Division of labor - Between pre-service teachers & students	have them explore this	Teachers want students to do some of the thinking.
		Socio-cultural practices - scientific & educational practice	explore this phenomenon	This is both a scientific practice as well as a science classroom practice (having students explore something).
		Mediating artifacts - Discourse	I wrote the word polarization	

Appendix I. Summary of CHAT codes

CHAT code		Total frequency	Percentage of total CHAT codes
Subject	students	52	3.7
	pre-service teacher	16	1.1
	Section subtotal	68	4.8
Mediating artifacts	discourse	238	16
	instructional materials	231	16
	instructional plan	72	5.1
	previous knowledge	43	3.0
	Section subtotal	674	48
Socio-cultural rules (practices)	educational practice	162	11
	scientific practice	107	7.6
	Section subtotal	269	19
Community		10	<1
	Section subtotal	10	<1
Division of labor	among students	12	<1
	between pre-service teachers	31	2.2
	between pre-service teachers & students	160	11
	between humans & computers	3	<1
	other	2	<1
	Section subtotal	208	15
Object		84	5.9
	Section subtotal	84	5.9
Outcome		104	7.3
	Section subtotal	104	7.3
Total CHAT codes		1417	

Appendix J. Example of voice-over transcript coded with identity framework

CATHY (CY)		ID-Related Codes	
Line #	Transcription	Codes	Code References
25	And so, next Stu just held up the concave lens and now we're asking them to do the same and predict, for what the concave lens is going on and, I'm giving them the four choices again, the four light rays coming through, whether they're coming together, going apart or, um, going straight through or reflecting.	teacher	we're asking them to do
		teacher	I'm giving them the four choices
26	And a lot of the students had them doing the exact same thing both times, which I thought was interesting because, I mean I guess because I already know, that, um, it just to me seemed counterintuitive.	student	I thought was interesting
		student	I mean I guess because
		scientist	I already know that
		scientist	it just to me seemed counterintuitive
27	But, I guess they're both glass, and so that made sense.	student	I guess they're both glass
28	And then, a lot of them also had the convex lenses with the light rays going out, is what I noticed in their pictures, and that's probably because, um, the shape of the lens bows out so they assume that the light rays would bow out as well.	teacher	what I noticed in their pictures
29	Um, also was noticing here that Stu and I tried to be very explicit in what we wanted them to draw but, definitely a concern for future lessons would be leading the students on too much and prompting them for answers.	teacher	Stu and I tried to be explicit
		teacher	what we wanted them to draw

Appendix K. Summary of identity-related codes

Identity code		Total frequency	Percentage of total identity codes
Clearly defined	Scientist	2	<1
	Student	258	18
	Teacher	877	63
	Class	94	6.8
Section subtotal		1231	88
Mixture	Class/Scientist	7	<1
	Student/Teacher	75	5.4
	Teacher/Class	75	5.4
	Ambiguous	4	<1
Section subtotal		161	12
Total identity codes		1392	