A study of the practices of three science teacher educators: the rule, "Do as I say, not as I do," ought not be the message

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A study of the practices of three science teacher educators:

The rule, "Do as I say, not as I do," ought not be the message

by

Crystal Noelle Bruxvoort

A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Education

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For the Major Program
DEDICATION

This work is dedicated to my family.

To my husband, Jim,
I admire your ceaseless devotion.

To my daughter, Liesl,
I admire your courage and compassionate way.

To my daughter, Mariel,
I admire your energy and spirit.

To my parents,
I admire your discernment and dedication to what really matters.

My love for all of you is true and steadfast.
I know you love me, too!
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This study explored the development of three science teacher educators as they interacted with preservice teachers while seeking to align their practices with what they were advocating in the elementary science methods courses that they taught. Practices that were advocated by the methods instructors were consistent with research-based teaching and goals of the science education community. The exploratory nature of this study warranted a qualitative research design using a grounded theory approach. Practices of the participants were observed during one aspect of the methods course--an oral defense--that served as the culminating evaluation of students' understanding. Evidence exists to support that the participants did not exhibit many advocated practices in their first three semesters, but gradually progressed overall, with periods of regression before more noticeable improvements. At times, a lack of improvement occurred. The participants struggled most when deciding how to respond to students, particularly when the students' previously conveyed ideas had errors. This study has implications for the preparation of teacher educators, particularly the role of mentoring and the need to acknowledge and develop pedagogical content knowledge unique to teaching methods.
CHAPTER 1: GENERAL INTRODUCTION

Background

Learning how to teach is arguably a complicated undertaking for preservice teachers (Munby, Russell, & Martin, 2001). Hence, teaching preservice teachers how to promote meaningful learning for children can be a daunting challenge. Multiple considerations, such as exposure to teaching as an occupation and job expectations of teacher educators, influence the efforts of teacher educators as they attempt to address aspects of this challenge.

By the time preservice teachers—students themselves—enroll in an education program at a college or university, they have been exposed to the teaching occupation for thousands of hours at multiple levels in their academic experience—kindergarten to college. While teaching as an occupation may be quite familiar to a person by the time one enters college, the inherent complexities involved in the act of teaching are likely concealed from students as they look on. Munby et al. (2001) write:

Although they have observed thousands of hours of teaching behavior, they have not been privy to the profound and extensive knowledge and thinking that underlies this behavior. As with any good performance, good teaching looks easy. When we witness a near-perfect performance in, say, the long program of a figure-skating competition, we recognize the many hours of intensive work that lie behind the apparent ease of execution under demanding circumstances. But we typically do not do this of teaching.
Indeed, teaching is so commonplace that successful, proficient, even artful teaching can be its own undoing. (p. 895)

The perception that teaching is easy is not only a contemporary notion, but also a view that has persisted for over a century. Educational reform documents from the 1890s to the present have advocated repeatedly for “simplistic prescriptions” (Goodlad, 1990a, p. xii) to diagnose and remedy problems encountered in schools. If these remedies were correct, one would expect the “teacher education enterprise would be in good health today” (Goodlad, 1990a, p. xii). However, it is not.

While preservice teachers’ views of teaching may underestimate the inherent challenges in teaching as a profession, they do affect how preservice teachers process information conveyed to them in their education coursework, particularly in methods courses. Methods courses present opportunities for general pedagogical content to intertwine with many perspectives (philosophical, psychological, and multicultural) in an effort to learn how to teach a specific discipline effectively, such as science or reading (Anderson, 1997). As preservice teachers are processing content in their methods courses (and in all courses) their previous ideas of teaching and learning selectively filter incoming information. Not surprisingly, this filtering process heavily influences how they conceptualize what they are learning about how to teach (Kagan, 1992). The influence of one’s previous views on how one conceptualizes new information is consistent with research on learning involving
conceptual change (Posner, Strike, Hewson, & Gertzog, 1982; Stepans, 1994; Watson & Konicek, 1990). Further, while preservice teachers’ views of teaching and learning may be inconsistent when compared to the views of their teachers, teacher educators now recognize that the views of preservice teachers are fixed and resistant to change no matter how inconsistent such views may be when compared to research on theory and practice (Feiman-Nemser & Buchmann, 1986; Pajares, 1992; Richardson, 1996; Tabachnick & Zeichner, 1984). Thus, teacher educators must create situations where preservice teachers are urged to confront errors in their current conceptions and radically alter their thinking to more closely align with research-supported views (Borko & Putnam, 1996; Bryan & Abell, 1999; Munby et al., 2001).

**Current State of Teacher Education**

Many educational researchers (e.g., Fullan, 1994; Goodlad, 1990a) claim that the success of the teacher education enterprise is still below par. While responsibility for the effectiveness of teacher education does not rest solely on teacher educators, certainly teacher educators play a part in the effort to improve the current state. In a massive five-year study of 29 teacher education programs in the U.S., Goodlad (1990a) researched many aspects of teacher education programs, including the practices modeled by teacher educators. Based on the results of this study, Goodlad (1990a) asserted that teachers of teachers struggle to “practice what they preach” (p.
75). In other words, inconsistencies exist between what teacher educators advocate and what they model when they teach methods coursework (Munby et al., 2001; Stoddart, Connell, Stofflet, & Peck, 1993). Goodlad (1990a) asserts that "for teacher education programs not to be [exemplary] models of educating is indefensible" (p. 59), especially given the powerful influence of modeling on learning (Lanier & Little, 1986).

One condition that undermines the efforts of teacher educators is the preeminence of scholarly publishing over teaching in college and university-based teacher education programs. Teacher education in so-called leading teacher education programs in the U.S. are known more for their study of education—not much of which has to do with pedagogy—rather than for exemplary records of preparing teachers (Goodlad, 1990a). In a sense, professors of education who study education are quite like professors of biology and geology who study natural phenomena. Goodlad (1990a) evaluated the propensity of professors of education toward the study of education by asking them to consider the following scenario:

There are two finalists for a position requiring a substantial commitment to the teacher education program. Both earned their doctorates at major research universities. One, the younger of the two, is fresh out of a three year post-doctoral fellowship with her major professor and has a substantial bibliography of papers published in refereed journals. She has not taught in elementary or secondary schools and is not particularly interested in teacher education, although she is well qualified academically for the course she would teach in the preparation program, and she is anxious to get on with
her research career. The other has taught a subject...in a secondary school...for several years and taught for three years in the teacher education program during her doctoral studies. But she has a much shorter list of publications (focused primarily on teaching and teacher education). She wants the job in teacher education, is well prepared to teach the specific courses and hopes to get some time and support for scholarly work. (pp. 89-90)

After posing this scenario to faculty groups on every campus in his study, Goodlad (1990a) asked faculty to choose the better candidate. When he did so, he gathered revealing evidence of the preeminence of research over teaching in schools of education. He writes:

There was little initial hesitation among faculty members in the research-oriented, beacon schools of education: The first of the two was the clear choice. Usually, however, we were not long into the exchange before someone said that there should be--or must be--room for the second kind of candidate or the institution might as well forget any serious interest in teacher education....Usually, faculty members agreed that participation in the teacher education program was good training for doctoral candidates, many of whom would teach in preparation programs, at least for a while. But most of these professors felt that working in teacher education programs was not for their graduate students. (p. 90, italics in original).

The sentiment conveyed by the faculty mentioned above is an indicator of the rise of research over teaching at many institutions including many large, research-based universities and even some smaller and more traditionally teaching-oriented colleges. This condition creates conflict within teacher educators who wish to advance professionally but who do not want to devalue their teaching (Zimpher & Sherrill, 1996). The implicit (and sometimes explicit) message to faculty in schools of
education is that while poor teaching may be tolerated, poor research is not. In the midst of education faculty juggling competing job responsibilities, preservice teachers are continuing to enroll in education courses and teacher educators continue to teach them. The practices exhibited by teacher educators fall short, though, of what they advocate that their students exemplify when they are hired as full-time teachers (Goodlad, 1990a). For instance, teacher educators who lecture about the benefits of eliciting students' prior knowledge through questioning, journaling, etc., convey confusing messages to preservice teachers (Stoddart et al., 1993).

A relatively small amount of research has been conducted on preservice teacher education (Conant, 1963; Sarason, Davidson, & Blatt, 1986; Tyack, 1989; Windschitl, 2005). Consequently, teachers of teachers, particularly what they do in practice and the impact of decisions they make, are unstudied typically (Lanier & Little, 1986). Additionally, little research has been published on how science teacher educators develop (Foley, 2004) as they attempt to model closely the practices that are consistent with research on teaching and learning in science education.

Better understanding how science teacher educators develop as they instruct in a methods course would create opportunities to foster the development of science teacher educators as they strive purposefully to improve their practice. First, once
the process of development is understood better, we can articulate better the pedagogical content knowledge unique to teaching science methods. Second, we can research the use of evaluative tools designed specifically to promote more accurate evaluation of one's practice as a science teacher educator. Third, we can research strategies, such as careful mentorship, to assist science teacher educators in improving their practice and respond to calls for reform in science teacher education more effectively. After all, few would argue that it is acceptable for science teacher educators to advocate one practice and exemplify another.

Purpose of Study

The purpose of this study was to explore the development of three science teacher educators as they sought to align their practices with what they advocated in science methods courses. Based on this exploration, recommendations are put forward to understand better and foster the professional development of less experienced science teacher educators who are trying to improve their teaching practices.

Research Questions

This study focused on two primary research questions:

1. In what ways do science teacher educators' practices change over time as they conduct oral defenses with students in a methods course?
2. How closely do science teacher educators conduct oral defenses in methods courses in ways that are consistent with advocated practices?

Terms

The meaning of many terms commonly used in education can be interpreted in myriad ways. To ensure clarity for the reader, the following is a list of terms commonly referred to in this study:

*Teacher educators* are defined as faculty members within schools of education who work with preservice teachers.

*Teacher education* consists of programs dedicated to preparing teachers to teach effectively in grades K-12. Teacher education can be divided into discipline-specific areas, such as math, social studies, and science. *Science teacher education* refers to the field of study within teacher education that specializes in teaching preservice teachers how to teach science effectively in grades K-12.

Teacher educators who specialize in teaching science are referred to as *science teacher educators*.

*Preservice teachers* are students who are enrolled in an education program for the purpose of learning to teach at the elementary, middle school, and/or high school level.
A *methods course* is a course in an education program that integrates content from many education and discipline-specific courses. For instance, knowledge of lesson plan strategies, educational psychology, special education, multicultural studies, classroom management and subject-specific content, such as math, science or reading, can be brought together and addressed in a holistic manner in a methods course. A *science methods* course is a specific type of methods course intended to prepare preservice teachers to teach science effectively in grades K-12.

A *methods student* refers to a preservice teacher who is enrolled in a methods course.

In general, the word *students* refers to college or university students who are enrolled in methods coursework within the context of an education program. In rare instances, the term *students* refers to children in grades K-12. Careful designations are used to indicate to the reader when an exception occurs. The term *children* is used more frequently to refer to students in grades K-12.

*Reform documents* refers to documents in science education, such as the *National Science Education Standards* (National Research Council, 1996), that call for improvements in how science is taught in grades K-12 and, consequently, how preservice teachers are prepared for this role.
In this study, the participants (science teacher educators) are observed conducting exit interviews with preservice teachers as a culminating evaluation in a methods course. For this reason, the term interviewer refers to one of the three participants as they conduct an exit interview with a preservice teacher.

The methods courses selected for study are designed based on a model called a research-based framework for teaching (RBF). In the RBF model and in this study, terms exit interview and oral defense are used interchangeably.

Effective teaching refers to practices that align with research-based ideas on teaching and learning as well as the goals broadly agreed upon in the field of science education. Research-based refers to practices that have been researched qualitatively and/or quantitatively in quasi-experimental studies, communicated to the field via publications in refereed locations (e.g., journals and books) and achieved consensus among scholars in the field.
CHAPTER 2: LITERATURE REVIEW

While teachers are only part of any nation’s total educational system, superb teachers can exert a significant influence on the quality of schooling at all levels of education (Cremin, 1961). However, embattled discussion ensues in various places—schools of education, state boards of education, federal policy-making bodies (e.g., U.S. Department of Education), disciplinary groups (e.g., National Science Teachers Association), teacher organizations (e.g., National Education Association), faculty and staff meetings—regarding the ways in which future teachers should best be prepared for challenges that they will encounter in their unique situations. Although many are connected with the responsibility of preparing teachers for our nation’s schools, college and university-based teacher education programs are held responsible for the quality of teachers and their decision-making in practice (Imig & Switzer, 1996; Sanders, 2004). Because modeling plays such an important role in learning, one critical component of teacher education is the instruction exemplified by teacher educators. This chapter presents literature that contextualizes the current efforts of teacher educators and establishes a warrant for this study. The chapter is divided into two main sections: (1) The current terrain facing teacher educators, including societal, programmatic, institutional, and student-related issues, and
research on teacher educators, including questions of identity, information on the current professoriate, and their preparation for their role.

Current Terrain Facing Teacher Educators

Explorers encounter unique challenges as they traverse uncharted territory. An explorer may be slowed if embarking with only a crude map in hand as a guide. Aspects of the terrain, such as a mountain range, a gushing river, or a tall-grass prairie, could affect one’s progress. Further, one’s progress could be affected in multiple ways; a river’s flow could assist in progress downstream, but greatly slow progress upstream. The nature of the explorer—one’s sense of adventure, knowledge of various terrains, physical stamina, preparations for the journey—impacts an explorer’s progress as well. Analogously, the progress of an explorer of sorts—a teacher educator—is influenced by many aspects including the surrounding “terrain.” Aspects to consider include society’s perceptions of the effectiveness of college and university-based teacher preparation programs, professional expectations of teacher educators, and features of teacher preparation programs that are intended to organize the courses taught by teacher educators into a coherent program. As sudden elevation changes can slow the progress of an explorer, so can the efforts of a teacher educator be impacted by shifts in the “terrain,” such as changes in societal expectations of teacher educators. In a manner of speaking, one
must first survey the terrain over which teacher educators traverse to understand better the efforts and the challenges set before them.

Society

Societal influences on the efforts of teacher educators include the conflicting ways in which the profession of teaching is viewed and the extensive exposure persons in society have had to experiences in school at all levels.

Conflicting Views of Teaching as a Profession

Teaching is fraught with contradiction in terms of society's regard for the profession (Berliner, 1986; Fullan, 1994; Goodlad, 1990a, 1990b; Lortie, 1975; Shulman, 1986, 2000). For instance, teaching is described as honorable while simultaneously referred to as easy; teaching is noble as well as reserved for those who can't do otherwise. Similarly, teachers are praised for their efforts while the occupation features income levels that are below those earned by persons with considerably less education (Farkas, Johnson, & Foleno, 2000; Goodlad, 1990a; Lortie, 1975). Society's ambiguous regard for teaching as a profession is described articulately by Lortie (1975):

Teaching, from its inception in America, has occupied a special but shadowed social standing. The services performed by teachers have usually been seen as above the run of everyday work, and the occupation has had the aura of a special mission honored by society. But social ambiguity has stalked those who undertook the mission, for the real regard shown those who taught has never matched the professed regard. Teaching is a status accorded high
respectability of a particular kind; but those occupying it do not receive the level or types of deference reserved for those working in the learned professions, occupying high government office, or demonstrating success in business. (p. 10)

Further, the contradictory ways in which teachers and teaching are viewed in society has remained relatively stable over time (Lortie, 1975; Tyack & Cuban, 1995).

In terms of distinguishing teaching as a profession, teaching is and remains only partially professionalized (Goodlad, 1990a; Hoyle, 1995; Lortie, 1975; Windschitl, 2005). According to Goodlad (1990a), conditions necessary to be recognized fully as a profession include: (1) a reasonably coherent body of knowledge and skills; (2) a considerable measure of ‘professional’ control over admissions to teacher education programs and of autonomy with respect to determining the relevant knowledge, skills, and norms; (3) a degree of homogeneity in groups of program candidates with respect to expectations and curricula; and (4) rather clear borders demarcating qualified candidates from the unqualified, legitimate programs of preparation from the shoddy and entrepreneurial, and fads from innovation grounded in theory and research. When judged by these criteria, Goodlad (1990a) and others assert that the teaching enterprise largely has not met these conditions. Hence, the enterprise of teaching is susceptible to further decline, particularly when stressed by unexpected circumstances, such as teacher shortages, disagreement regarding what is required to learn to teach, and decisions made by
governing bodies (e.g., school boards, government departments of education) that are political, but not run by experts in teaching.

In short, teaching is highly regarded and noble--but for somebody else. Yet universal schooling remains a foundational principle upon which a democratic system is founded; thus, the quality of a nation's schooling remains an eminent responsibility of teachers and teacher education (Dewey, 1916; Goodlad, 1990a; Sanders, 2004).

**Exposure to Teaching**

Unlike most other occupations, people are highly exposed to teachers' activities from an early age. The sheer number of hours in one's life spent in direct contact with teachers powerfully influences how one views the occupation of teaching (Feiman-Nemser & Buchmann, 1986; Fullan, 1994; Hollingsworth, 1989; Lortie, 1975; Skamp & Mueller, 2001; Stoddart et al., 1993). Lortie (1975) writes:

Those who teach have normally had sixteen continuous years of contact with teachers and professors. American young people, in fact, see teachers at work much more than they see any other occupational group; we can estimate that the average student has spent 13,000 hours in direct contact with classroom teachers by the time [one] graduates from high school. That contact takes place in a small space; students are rarely more than a few yards away from their teacher. (p. 61)

Interactions between teachers and students at all levels (K-college) has important consequences for a student's perception of what teachers consider when
making decisions. Any student, particularly one who has aspirations of attending college after high school, learns to consider how a teacher might react to a particular situation, and thus is likely to project himself or herself into the teacher’s position (Lortie, 1975). A student who wants to be a teacher is even more likely to do so. Further, as students project themselves into a teacher’s position, a confounding problem arises:

...good teaching looks easy....Indeed, teaching is so commonplace that successful, proficient, even artful teaching can be its own undoing. Because those of voting age have experienced its apparent effortlessness, teaching seems in no need of political champions. Good teaching in the eyes of those taught unwittingly reinforces this view of teaching, and its manifestations suggest strongly that, if some of its students should wish to become teachers, all they need to do is attend a teacher education program, acquire the skills, and then practice them. Certification and good teaching will follow. (Munby et al., 2001, p. 895)

In other words, students perceive that, after spending time in contact with teachers in various classrooms, teaching is not all that difficult and time spent as a student qualifies oneself as at least an “armchair expert” (Feiman-Nemser & Buchmann, 1886; Fullan, 1994; Lortie, 1975; Shulman, 2000). Additionally, even though students observe poor teaching as well as good teaching and even though they can tell some differences between good and poor teaching, they rarely see evidence of different treatment of good and poor teachers. Poor or mediocre teachers of equal experience are compensated similarly, and usually they are no more in risk of losing their job
when compared to excellent teachers (Lortie, 1975). Students seem to follow this model and come to accept mediocre teaching as fully acceptable.

Given that impressions made on students are generally oversimplified realities of teaching, there are limits on the extent to which being a student at any level of education can prepare a person to be a teacher. While teachers are making decisions in practice, they generally do not share with students their rationales or personal reflections. Thus, according to Lortie (1975), students are not pressed to place the teacher's actions in a pedagogically oriented framework....They assess teachers on a wide variety of personal and student-oriented bases, but only partially in terms of criteria shared with their teacher and with teachers in general. It is improbable that students learn to see teaching in an end-means frame or that they normally take an analytic stance toward it. Students are undoubtedly impressed by some teacher actions and not by others, but one would not expect them to view the differences in a pedagogical, explanatory way. What students learn about teaching, then, is intuitive and imitative rather than explicit and analytical; it is based on individual personalities rather than pedagogical principles. Imagining how the teacher feels and playing the role of the teacher are different experiences. (p. 62)

Because students are not educated in how to teach, and lack the empathy and knowledge needed to evaluate teachers' decision-making accurately, there seems relatively little basis for assuming that students make careful, thoughtful, and accurate assessments of the quality of teaching to which they have been exposed (Lortie, 1975).
Preservice teachers who have just exited their K-12 educational experience and who now enter an undergraduate program in teacher education will continue to evaluate their professors of education as they did their teachers in secondary, middle, and elementary school. Lortie (1975) argues that the response of preservice teachers to the instruction they receive from professors of education is unusual compared to how college students view instruction by professors who are teaching in other areas of expertise:

One thinks, for example, of the engineering student’s relationship to his professors. Given the complexity and low visibility of engineering tasks and specialties, it is an unusual student who rejects, or even screens, professorial dicta on the basis of personally formulated judgments about engineering practice. But education students have spent years assessing teachers and many enter training with strong perceptions based upon firm identifications. Students in education may classify education professors as new members of a category (teachers) with which they are already most familiar. (p. 66)

Preservice teachers place value on their personal experiences in education from both before and during their instruction in college and university-based programs of education. Of course, while preservice teachers are experiencing coursework in teacher education, they have a new opportunity to view the experience from the inside and to insert themselves into this picture. Hughes (1958) describes this process of looking back on one’s former self from the inside and then reversing one’s preconceptions as an important turning point in professional socialization. Further, most pre-professionals undergo this reversal. However, Lortie
(1975) noted that when ninety-four teachers (elementary through secondary) in five towns of varying socioeconomic status in the Boston metropolitan area (The Five Towns Study) were interviewed, they remarkably did not fit with Hughes' description. These teachers, albeit a limited sample, placed events preceding their formal preparation for teaching within a continuous rather than a discontinuous framework. When these teachers described their former teachers, they did not contrast their conceptions conceived as a student with a later, more sophisticated viewpoint. Preservice teachers "talk about assessments they made as youngsters as currently viable, as stable judgments of quality. What constituted good teaching then constitutes good teaching now; there is no great divide between preentry and postentry evaluations" (Lortie, 1975, p. 65-66). Thus, the challenges encountered by teacher educators are likely to differ from any other occupation because of the extensive exposure people have had to teaching, the resilience of the ideas they form during this exposure, and the extent to which preservice and inservice teachers act on their previously formed ideas.

**Programs**

Conceptualization of what is involved in educating preservice teachers relies upon an understanding of teacher education from its historical beginnings. This context aids in understanding the seriousness of challenges encountered by teacher
educators today. Within this discussion, the evolution of the purpose of teacher education and repercussions of a splintered, but crucial purpose will be examined.

**The Normal School Movement**

Considering our nation's history of more than three centuries of schooling, creation of a formal system to prepare teachers to teach is relatively recent (Lortie, 1975). As Lortie (1975) writes, "for almost two hundred years, those who taught school received no special preparation," and "although provision was made for such instruction around the middle of the nineteenth century, it was at least seventy more years before most teachers had special training" (p. 17). Teaching was not a standardized profession during colonial times; thus, the qualifications of those who taught in schools during this time varied widely, as some grammar school teachers possessed first-rate college preparation while others had considerably less schooling (Cremin, 1970). Teachers typically were licensed a year at a time by school boards consisting of decision-makers who were reputable citizens in a community, such as ministers and doctors, who used no existing established criteria for entry, but who attested to the qualifications of those who were hired (Lortie, 1975). However, teachers, in general, were expected to exhibit moral character, proficiency in the subject matter to be taught, and the ability to wield control in a classroom.
Creation of a designated center for systematically preparing teachers occurred in 1839 with the opening of the first public normal school (Lortie, 1975; Goodlad, 1990a). This occurrence took root in the Northeast, where a renaissance was occurring between 1830 and 1850 (Borrowman, 1956). Leaders of this renaissance were men such as Ralph Waldo Emerson and Henry David Thoreau. Emerson, a critic of materialistic, anti-intellectual, and pragmatic Americans, paradoxically expressed ideas that resonated with many people as he emphasized basic ideas of equality, individualism, and progress. Expression of these ideas and the ways in which the ideas resonated with the public gave impetus to educational reform. However, Borrowman (1956) notes that it is a mistake to assume that all of New England was motivated by these ideals, for, “as late as 1838, Noah Webster was pleading that the Federal Constitution be revised to give a permanent recognition for the distinction between rich and poor and to save the country from democracy by granting the rich a permanent role in government” (p. 36). Issues of class structure and repercussions of such a system were perceived by some leaders as a crucial threat to the cohesiveness of the American community. In the face of this threat, the idea of a common school was created that would be attended by all groups and classes, commonly supported and controlled by an entire community and that would provide the knowledge required for “Christian virtue and for
economic and political competency” (Borrowman, 1956, p. 36). Pioneers of the common school almost immediately saw the need to create a special institution for preparing teachers to teach in this setting. In response to this need, normal schools were created. Samuel R. Hall opened his private normal school at Concord, Vermont, in 1823 and shortly thereafter, in 1827, James G. Carter opened a similar school at Lancaster, Massachusetts. New York State followed in 1834 by providing grants of public money to promote professional teacher education in the academies. Finally, in 1839, in response to the relentless efforts of such men as James G. Carter, Charles Brooks, Calvin Stowe, Horace Mann, and Edmund Dwight, Massachusetts established the first of the public, single-purpose normal schools (Borrowman, 1956). The opening of the first public normal school was followed shortly by the establishment of many others.

Given the close tie between normal schools and the common school, curricular decisions early in the history of normal schools largely reflected what was taught in common schools (Borrowman, 1956; Goodlad, 1990a). An education in the early period of common schooling (although constantly pressured to expand) generally emphasized instruction in the so-called common branches--reading, writing, and arithmetic--plus spelling, geography, grammar, and perhaps a bit of physiology, history, and ethics or religion (Borrowman, 1956). Obviously any
institution designed to serve another must be close enough to the institution to understand the experiences of those who are being served; however, such a relationship did not necessarily impose a certain limitation on decisions regarding the normal school curriculum. Yet, partly by circumstance and partly by school leaders' deliberate intent, the normal school curriculum was limited to content addressed in the common school. Thus, students in normal schools (preservice teachers) generally had attended elementary school for a few years, gone directly from there to study at a normal school and then returned shortly after graduation to teach the lower grades in an elementary school (Borrowman, 1956).

Disagreement regarding what should be taught in a normal school curriculum continued beyond the inception of normal schools. Many normal school leaders opposed a curriculum limited exclusively to elementary school subject matter. For example, William F. Phelps, the first principal of the Trenton (New Jersey) State Normal School repeatedly argued in public forums, "How are you to teach them how to teach that of which they know nothing?" (Borrowman, 1956, p. 45). When Phelps proposed a curriculum, he included a number of courses usually offered in the academies and colleges including algebra, geometry, natural science (chemistry, geology, and physics), and moral philosophy. Yet, Phelps reported that while he hoped for such an emphasis in normal school curricula beyond the content
in common schools, he reported that in reality the courses that were taught focused mainly on common school curricula, such as spelling, word analysis, reading and elocution, arithmetic, geography, drawing, and music. Others took a stance opposing Phelps’ view; for instance, Horace Mann (1939, as cited in Borrowman, 1956) stated:

One of the most cheering auguries in regard to our schools is the unanimity with which the committees have awarded sentence of condemnation against the practice of introducing into them the studies of the university to the exclusion or neglect of the rudimental branches. By such practice a pupil foregoes all the stock of real knowledge he might otherwise acquire; and he receives, in its stead, only a show of counterfeit knowledge, which, with all intelligent persons, only renders his ignorance more conspicuous....For these and similar considerations, it seems that the first intellectual qualification of a teacher is a critical thoroughness, both in rules and principles, in regard to all the branches required by law to be taught in the Common Schools; and a power of recalling them in any of their parts with a promptitude and certainty hardly inferior to that with which he could tell his own name. (p. 45)

At the time when normal schools were growing in number, little thought was given to the notion of pedagogy. Pedagogy, as it was, consisted of what today would be viewed as helpful hints for classroom management, establishing routines and the like (Goodlad, 1990a). Later, however, as more thought was given to the notion of pedagogy, debate ensued as to how much pedagogy future teachers should be taught. Some argued for content knowledge only. Others argued for teaching content knowledge, but doing so differently by coupling instruction of specific subject matter with discussion of how to teach the subject more effectively.
Learned, Bagley, McMurry, Peabody, Dearborn, and Strayer (1920) described this debate:

[For some], the purpose of the [normal] schools should be solely to teach subject-matter properly; it was said that students would teach precisely as they had been taught, and could shift for themselves if filled with ideas to be communicated. According to [others], only the indispensable subject-matter should be given; the main purpose should be to develop the philosophy of method and to test the skill of the candidate in using methods. (p. 196-197)

Persons such as Richard Edwards, former president of Illinois Normal University, argued for a commitment toward content that aligned more closely with the latter purpose described above. Edwards (1865, as cited in Borrowman, 1965) writes:

In an ordinary school, the treatise on arithmetic is put into the hands of the students in order that he may learn arithmetic; in the Normal School, the same book is used to enable him to learn how to teach arithmetic. In the ordinary school, the youth reads his Cicero with the purpose of learning the structure, vocabulary, and power of the Latin language; the normal student pores over the same author that he may adjust in his mind a method by which he may most successfully teach others these things. Both use the same materials, acquire, to some extent, the same knowledge, but aiming all the while at different ends. (p. 76, italics in original)

While debates on the issue of content knowledge versus method were eloquent and heated, these discussions quieted eventually as the purpose of normal schooling began to shift away from its original intent as a place solely designed to prepare teachers.

While messages like those of Richard Edwards as described previously were clear and insistent, voices of others began clamoring for normal schools to do more.
The message that gained clarity and support over time argued for normal schools to have more than a single aim; they should provide additional course offerings for people who did not necessarily intend to teach. To this end, coursework in general education for various levels of education was included eventually in the normal school curriculum. With these changes, some normal schools now looked similar to institutions resembling an extension or adaptation of a high school education. By 1900, some normal schools even resembled colleges (Altenbaugh & Underwood, 1990; Goodlad, 1990a). Changes in the normal school curriculum now reflected a convenient and inexpensive schooling option to persons who did not necessarily consider themselves as preservice teachers (Goodlad, 1990a). Comparing early public announcements distributed to prospective students by normal schools to later publications reveals such a shift in purpose. Early on, superintendents of normal schools claimed that “no effort has been spared to make the institution exclusively a school for teachers” (Learned et al., 1920, p. 186). Similarly, students attending normal school “should feel behind him a full tide of pressure from every quarter urging him to teach and to do nothing else, and he should contribute the impetus of his own clear decision to [this] general impulse” (Learned et al., 1920, p. 204). Later on, however, announcements published by normal schools advertised to make “first educated men and women,” while emphasizing “a broad academic foundation”
where “studies considered ‘academic’ were set off sharply from those termed ‘professional’” (Learned et al., 1920, p. 198). Further, normal schools originally mandated entrants to sign a statement committing to teach in public schools upon graduation; however, eventually this language was dropped from their school materials as others, besides future teachers, began attending the institutions.

While normal schools were intended to improve the quality of teaching in public schools across the nation, Tyack (1967) indicated that by the end of the nineteenth century, normal schools prepared only a minority of teachers. Most teachers employed in schools before 1900 had only grade-school educations; however, this period near the end of the century was a time of steady change. Certification by school boards was replaced by state certification, which eventually included required completion of prescribed courses of study in colleges and universities (Lortie, 1975; Yager & Penick, 1994). Even though as late as 1921 most states had no specific scholarship requirement for teaching (fourteen required only high school graduation and a smaller number required some special work in education), a major change had taken place by 1937. By the late 1930s, thirty-two states required teachers to have more than high school coursework as preparation (Lortie, 1975). The importance of teachers having a college education (ranging from
one to four years) had gained momentum and was becoming integral in the process by which teachers gained certification.

Changes occurring at the turn of the nineteenth century forecast an end to the era of normal schools. By 1940, normal schools had become other kinds of institutions in both name and purpose (Goodlad, 1990a). Normal schools gave rise to teachers’ colleges, but teachers’ colleges experienced an even shorter life than normal schools. By the early 1970s, teachers’ colleges had evolved into schools of education within colleges and universities. Association with institutions of higher education seemingly was expected to promote respect for teacher education; however, this era of transition instead resulted in a severe loss of identity in teacher education (Altenbaugh & Underwood, 1990; Lanier & Little, 1986; Goodlad, 1990a, 1990b). Teacher education was not so much cast aside as it was overshadowed as it became one of several competing functions set forth by institutions of higher education (Goodlad, 1990b). Ultimately, this overshadowing effect detracted from the primary business of preparing teachers to teach (Zimpher & Sherrill, 1996).

A study of the normal school movement, which began in 1839, reveals evidence of a struggle for purpose and a splintered identity for teacher education. As normal schools began to offer secondary and sometimes college-level coursework, the student populations in these schools eventually consisted of
persons who did and who did not necessarily intend to teach. Indeed, it was in the best interests of these latter students for normal schools to become increasingly diverse in their functions and curricula because normal schooling became the most inexpensive and accessible source of general and vocational education of the time (Goodlad, 1990a). However, a lack of clearly defined criteria for teacher certification and division concerning what teachers most need to be prepared to teach resulted in a splintered identity and focus for teacher education which, while beneficial to some, did not necessarily best serve teacher education (Goodlad, 1990a). Although more than 150 years has passed since the beginnings of teacher education, the problems and current debates in education, including what and how preservice teachers should be taught, remain remarkably similar (Cuban, 1984; Lanier & Little, 1986).

**Ease of Entry and Effects of Recruitment**

Confusion regarding the purpose of teacher education and who is most qualified to teach is confounded by the entry processes of education programs as well as the effects of teacher candidate recruitment. Numerous options exist to attract candidates into various professions, such as lowered entrance requirements or increased levels of compensation. In the case of teaching, Lortie (1975) asserts that society has preferred to attract future teachers to the teaching profession “by easing
access" (p. 23). Ease of entry is facilitated by: (1) non-elitist admission standards/highly accessible training, (2) a wide decision range, and (3) the subjective warrant (Lortie, 1975).

Non-elitist admission standards are evident in that teacher education programs do not have the stringent entrance requirements observed in other occupations (e.g., medicine and law). Further, while other occupations require longer periods of preparation (e.g., doctors are required to fulfill prerequisite requirements, attend medical school, and then fulfill a residency position), the short duration needed to obtain a teaching license makes it possible for persons to decide to teach at a wide range of points throughout their life. Additionally, Lortie (1975) claims that it is important to consider what people believe is necessary for success in a given role--referring to what he calls the subjective warrant. When ninety-four teachers (elementary through secondary) in five towns of varying socioeconomic status in the Boston metropolitan area (The Five Towns Study) were asked by Lortie (1975) what most qualified them for their role, they mentioned interpersonal qualities (patience, a sense of humor, leadership ability, and a calm demeanor) and preferences ("I like children") more than three times as often as intellectual attributes. While this study involved a limited sample, Lortie (1975) argues that the results command attention. These data describe qualifications for entry into the
profession that are not stringent and likely discourage few when they consider whether they have the necessary qualities to be a teacher. This subjective warrant, coupled with the wide decision range and non-elitist admission standards work together to ease entry into teaching, poses intriguing challenges for teacher educators who are most held accountable for the quality of teaching displayed by practicing teachers.

In an age characterized by an outcry for educational reform, careful recruitment of teacher candidates could serve as an effective method to initiate improvement in the quality of schooling; however, in actuality recruitment of preservice teachers fuels constancy rather than change in education (Cuban, 1984). Constancy is fueled because those who select teaching as an occupation typically are people who are favorably disposed toward the existing, more traditional system of education (Lortie, 1975). Teachers who succeeded previously in school are less likely to alter the current system and, as a consequence, may lack the desire to pursue educational reform. Further, a real risk exists that teacher education programs attract those who like children, but who may not have the intellectual capacity to deal with the complex cognitive demands associated with effective teaching. Additionally, even if novice teachers were in a position to act as change agents, the system of education itself is strongly resistant (Cuban, 1984). Thus, teacher
educators are pressed from various sides, as recruitment of teacher candidates and
the educational system itself resist change amidst society’s cries for educational
reform.

**Teacher Shortage and Alternative Certification**

The realities of a teacher shortage compounds challenges faced by teacher
educators in education programs. According to Zimpher and Sherrill (1996),
scholars who study the American educational condition, such as Hargreaves and
Fullan, assert that teacher education is in the midst of profound change
characterized by a shortage of teachers, especially in the areas of math, science and
technology, and which is particularly severe in urban centers (Craven & Penick,
2001). One method intended to address the severity of a current teacher shortage
involves reducing admissions requirements into the profession. Today, this change
takes the form of alternative certification programs. Such programs certify teachers
in a more efficient manner by bypassing the conventional route to certification
through colleges or schools of education (Baines, McDowell, & Fouk, 2001; Darling-
Hammond & Youngs, 2002; Windschitl, 2005; Zimpher & Sherrill, 1996). What sort
of preparation are prospective teachers receiving when they become certified using
alternative certification programs? Windschitl (2005) writes:

> In at least three states, prospective high school teachers are not required to
have studied curriculum, teaching strategies, classroom management, uses of
technology, or the needs of special education students. They essentially bypass teacher education altogether (Galley, 2004; Georgia Professional Standards Commission, 2004; Keller, 2004). These states make no provisions at all for student teaching as compared with 18-week requirements in Wisconsin and Minnesota (NASDTEC, 2000). Idaho now accepts, as the sole basis of teacher certification, successful passage of online exams administered through the federally approved American Board for Certification of Teacher Excellence (U.S. Department of Education, 2003). School districts all over the United States are developing state-approved alternative routes to certification, some of which meet or exceed normal licensing standards, while others offer only a few weeks in training that do not include learning theory, child development, or content-specific methods. (p. 526, italics in original)

Many authors (e.g., Craven & Penick, 2001; Goodlad, 1990a; Windschitl, 2005) assert that alternative certification programs do little more than undermine public and private conceptions of the profession, teachers, and those that teach teachers.

Winschitl (2005) writes:

There is serious ethic subtext associated with this state of affairs [regarding the acceptance of alternative certification programs]. The logic behind forgoing preparation depends on a view of teaching as a second-class profession or a short-term public service “gig” rather than as an intellectually demanding career in which one develops as a professional over years. In this simplified world, teachers are technicians who merely administer curriculum designed by others and follow set routines of instruction to unproblematically deliver knowledge to students—all of what is important to know about teaching (beyond content knowledge) can be learned “on the job.” To support this conception of “educator as altruistic temp worker,” one must deny that teaching is a field of inquiry with an underlying knowledge base and somehow ignore decades of research in learning and teaching, or at least dismiss it all as nonscientific. When people enter this intellectually demanding profession without specialized knowledge or reflective frames of thinking, they have little recourse but to reproduce the patterns of instruction that they remember experiencing as students. (Winschitl, 2005, p. 527)
Learning to Teach

As alternative certification programs gain momentum and the effectiveness of teacher education programs is questioned, teacher educators must consider a pressing question regarding the design of an effective teacher education program. The pressing question today, as noted in the history of teacher education as well, is: What knowledge is necessary as one learns to teach effectively? Further, teacher educators must consider this question in view of how preservice teachers--students themselves when enrolled in teacher education coursework--learn.

Literature supports that teachers (and teacher educators) draw from a complex interplay of knowledge bases (Borko & Putnam, 1996; Calderhead, 1996; Christensen, 1996; Munby et al., 2001; Sanders, 2004; Shulman, 2000; Sparks, 1997; Uhlenbeck, Verloop, & Beijaard, 2002). The interplay among these knowledge bases is exemplified using the following illustration (Shulman, 2000). Imagine that you are asked to perform a common mathematical activity (i.e., dividing fractions). After performing the mathematical activity, you are then asked to consider how one would explain the method by which you arrived at your answer. How might your explanation differ if you were designing an explanation for various people, such as a group of third graders, a graduate student who writes on 18th century English
poetry, or an undergraduate psychology major who just finished her first statistics course? Shulman (2000) writes about this exercise in the following reflection:

As you begin to experience the difference between what it means to know and understand something yourself and what it takes to help someone else come to know and understand it, and as you begin to recognize the complexity of that process, you have come a very short distance into studying the problem of learning and teaching. (p. 130)

Through the experience of coming to understand (knowing) and creating situations to foster others' understanding (teaching), one begins to fathom the expertise unique to a teacher, and particularly a teacher educator. Thus, teacher educators face a unique challenge on two levels when designing instruction for preservice teachers. These two levels include designing instruction to address subject-specific content, such as earth science, math, or biology, as well as designing instruction on learning how to teach that content.

One knowledge base, in particular, from which teachers draw when making decisions is called pedagogical content knowledge (PCK). In Shulman's pioneering work, the construct was described as a form of subject matter knowledge that had been transformed for the purpose of teaching. A growing number of researchers now refer to PCK, but define the construct in somewhat different ways, emphasizing different issues (Zohar & Schwartz, 2001). PCK is not merely the summation of subject matter knowledge and pedagogical knowledge (Paulsen, 2001). Loughran,
Gunstone, Berry, Milroy and Mulhall (2000a; 2000b) assert that PCK is a complex interplay of elements which, when combined, help give insights into PCK in a given content area. These researchers and others (e.g., Van Driel, Verloop & Voss, 1998) emphasize the need for additional research on PCK in specific areas. To date, research on PCK related to teaching the content of methods coursework has not been conducted.

Consensus has not been reached regarding what constitutes the intellectual knowledge base required to teach effectively (Hoyle, 1995; Lanier & Little, 1986). Many argue that a substantial knowledge base underlies the practices of effective teachers, but is either underutilized or unrecognized by teacher educators as well as teachers in the field (Munby et al., 2001; Zimpher & Sherrill, 1996). Further, Hoyle (1995) argues that when teachers themselves (and outsiders) underutilize an intellectual knowledge base when making decisions in practice, they must confront an underlying consequence of this decision-making:

If [teachers] criticize the theory to which they have been exposed in their training as irrelevant to practice, they are denying to themselves one of the traditional characteristics of a profession. If teaching is no more than an experience-based skill with a limited set of precepts, the occupation is indistinguishable from the crafts of, say, plumbing or motor mechanics (p. 13).

Assisting preservice teachers in constructing a more sophisticated understanding of what constitutes effective teaching is a daunting challenge for all
teacher educators in any subject domain. Preservice teachers’ overly simplistic and often inaccurate views of effective teaching act as a selective filter through which preservice teachers process not only their teacher education coursework, but also practica and student teaching experiences (Kagan, 1992; Leinhardt, 1992; Skamp & Mueller, 2001). Further, preservice teachers do not readily discard or alter their preconceptions to be more sophisticated, a process termed by researchers as the process of conceptual change (Champagne, Gunstone, & Klopfer, 1983; Dreyfus, Jungwirth, & Eliovitch, 1990; Hewson, 1981; Posner et al., 1982; Strike & Posner, 1985, 1992).

Researchers who made deliberate efforts to confront preservice teachers’ naive ideas found that, even when students were confronted with conflicting new information, students still strongly resisted shifting their ideas to more accurate views (Bryan & Abell, 1999; Feiman-Nemser & Buchmann, 1986; Pajares, 1992; Richardson, 1996; Tabachnick & Zeichner, 1984). Indeed, preservice teachers—and all learners—cling tenaciously to their prior conceptions (Driver, Guesne, & Tiberghien, 1985; Hewson & Hewson, 1984; Watson & Konicek, 1990). Thus, teacher educators have a great deal to consider as they design instruction intended to promote conceptual change in preservice teachers’ ideas about teaching and learning (Munby et al., 2001; Stofflet, 1994; Thorley & Stofflet, 1996).
Institutions

Institutions that employ teacher educators convey both implicit and explicit messages about the status of teacher education. Further, institutional expectations of teacher educators regarding promotion and tenure can be conflicting for teacher educators when they are judged professionally on scholarship above teaching.

Lack of Prestige for Teacher Educators

Regarding college and university faculty status and prestige in undergraduate and graduate-level academic settings, Lanier and Little (1986) argue that an inverse relationship exists between professorial prestige and the intensity of involvement with the formal education of teachers. University faculty and administrators “remain just close enough to teacher education to avoid entrusting it to the ‘teacher educators,’ and they remain sufficiently distant to avoid being identified with the enterprise” (Lanier & Little, 1986, p. 530). Faculty in the arts and sciences risk losing status if they assume clear interest in or responsibility for teacher education. Persons of similar academic rank risk never earning respect from or losing the respect of their counterparts of equal rank in other departments. The previously mentioned principle set forth by Lanier and Little (1986) explains how respect is stratified on college campuses, with education professors who actually
supervise prospective or practicing teachers in elementary and secondary schools at
the bottom of the stratification ladder.

**Rise of Research**

A second reason contributing to the prestige deprivation experienced by
teacher educators is the rising importance of research in major institutions (Goodlad,
1990a). Professors of education in research-oriented universities have more to
consider in terms of promotion than educating effectively. Promotion depends
heavily on research activity, teaching effectiveness, institutional service and
professional activity, although contributions in the last three categories fail to cancel
a lack of research activity (Hendrick, 1990). In other words, excellence in research is
demanded for promotion along with only satisfactory performance expected in all
other responsibilities:

The pecking order of major universities depends almost entirely on the size of
their extramurally funded research budgets and the visibility of their faculty
as evidenced by publications based on their research. Visibility built on
research activity and publication in prestigious journals provides both career
mobility and comforting assurance of being wanted….A colleague may be
recognized as a gifted teacher, but such a reputation will not carry far beyond
the local campus and certainly will not provide equal mobility and monetary
rewards. (Goodlad, 1990b, p. 23)

Goodlad (1990a) asked faculty at major research universities to describe their
perceptions of their work responsibilities and concluded that faculty are more
inclined to study teachers, much like biologists study biology, than to prepare them.
Professors in schools of education at smaller, regional universities and colleges are not exempt from the influence of the rise of research (Burgess, 1990). In these settings, where teaching is more heavily emphasized, an emphasis on research and scholarly productivity is increasingly evident. Research in these institutions is said to be an add-on to the traditional expectations of teaching and service; however, professors in these institutions have become resentful as the expectation to publish occurs amidst teaching heavier course loads and a lack of support for scholarship (e.g., little mentorship from senior faculty conducting research, few graduate students, lack of secretarial support).

Changes related to the rise in importance of research-related activity in schools of education are problematic for many in teacher education including preservice teachers. Preservice teachers are not naïve to what is occurring around them:

On the one hand then, teacher education in the major universities is turned over to doctoral-level students and a variety of part-time and adjunct instructors, clearly conveying the message that the enterprise is of minor importance. On the other hand, in the regional universities, where most teachers are prepared, faculty morale is lowered because the activities from which they formerly derived personal rewards and satisfaction no longer appear to lead to professional recognition. None of this is lost on students in teacher education programs. They generally do not see themselves as central to university function and faculty purpose. (Goodlad, 1990b, p. 25-26)
Clifford and Guthrie (1988, as cited in Zimpher & Sherrill, 1996) caution, "the more forcefully [schools of education] have rowed toward the shores of scholarly research, the more distant they have become from the public schools they are duty bound to serve" (p. 280). Ironically, however, Judge (1982) asserts that, as schools of education draw closer to K-12 schools, they become increasingly associated with the prestige deprivation of K-12 teachers. In other words, if K-12 teachers could achieve a greater status, then schools of education would do the same.

**Student Issues**

Student-related issues with which teacher educators must contend include personal perceptions of one’s preparation, typical cognitive and personal attributes of preservice teachers, and perceptions of what one needs to teach effectively.

**Description of Teacher Candidates**

Various reports claim that the best and the brightest U.S. college graduates are not being attracted to education, but seek employment in other careers. However, Lanier and Little (1986) argue that these reports are misleading to an extent. First, they claim that arguments that the best college graduates are not deciding to teach, but choosing other careers, is patently false. The percentage of top college graduates deciding to teach is not unlike the percentage of students who decide to enter medicine. Second, they assert that these reports fail to consider a
salient point related to the massive number of teacher candidates needed to fill currently available teaching positions:

If a small population is needed, aspirations to obtain recruits from the very top can be realistic. As an occupation grows from 200, to 2,000, to 20,000, or to 200,000, the goal of getting recruits from the upper quartile of the college population becomes increasingly difficult. (Lanier & Little, 1986, p. 537)

Unquestionably, the United States has expressed a verbal commitment to equal education opportunities for all citizens. However, the magnitude of the responsibility on teacher education to generate a teaching force needed to support mass schooling is so large “that the U.S. must look to more or less average students, as well as to the highly talented, if it is to acquire enough teachers for its classrooms” (Lanier & Little, 1986, p. 539). Needless to say, teacher educators must consider a challenging dynamic created by mixing “more or less average students” with high achieving students in the same course.

While the debate as to what is necessary to teach in educational programming continues to rage, the perceptions of preservice teachers themselves in terms of what they need continue to further complicate the debate. Teachers claim that the key to legitimation as a teacher is not formal preparation, but personal experience (Appleton, 2002, 2005; Hargreaves, 1995; Lortie, 1975; Munby et al., 2001; Ohana, 2004). Preservice teachers and practicing teachers carefully consider whether to incorporate a new strategy into their repertoire using a personal screening process.
For instance, if teachers observe a colleague using a new teaching strategy, they will not incorporate that strategy into their repertoire unless they are convinced that the new practice is fitting for their personality, personal style of teaching, and their particular situation. In other words, teachers described that they would not use a new practice routinely until they had tried it in their classroom and found that it worked for them. Further, the personalized aspect involved in teachers' decision-making is even more manifest when practicing teachers justify their decision-making on the basis of their individual experiences as students (Lortie, 1975). In this instance, the argument is that what worked for me as a student surely will work for others, despite all other considerations. A direct consequence of this position is a lack of credibility in the public's eye when teachers cannot justify and articulate clearly why they made educational decisions as they did (Fullan, 1996; Olson, in press).

One might expect preservice teachers and practicing teachers--of all people--to be supportive of the teacher preparation that they received. After all, such support would lend credence to the belief that one is not necessarily qualified to teach because of past experiences as a student and/or parent. However, while teachers believe that teaching is highly complex and requires more than subject matter preparation, teachers are not strong defenders of the preparation they
received in teacher education (Anderson, 1996; Farkas et al., 2000; Lortie, 1975; Sanders, 2004). Lortie (1975) reported that teachers are inclined to talk about their teacher preparation as easy ("mickey mouse") and complain that coursework is not all that rigorous (p. 160). More specifically, teachers are critical of the preparation they received regarding practical aspects.

Data gathered from beginning teachers by Hermanowicz (1966, as cited in Lortie, 1975) showed that teachers criticized the more practical courses in their teacher preparation on two grounds: (1) they did not have enough practice courses and, (2) the practice courses that they did have did not meet their expectations. Further, practicing teachers complained that the instruction they received in teaching methods was "too theoretical" and "too thin" (p. 68). In the students' views, "too theoretical" meant that the goals promoted in such courses "proffer[ed] impractical expectations and a utopian conception of classroom reality (Lortie, 1975, p. 68) and "too thin" meant that the courses were repetitive and boring. These twin allegations of teaching methods being "too theoretical" and "too thin" seem to imply that "professors of education inculcate high and difficult goals in students without providing the means for their achievement" (Lortie, 1975, p. 69). When practicing teachers find themselves short of the goals set before them, they are confronted with a choice: They must choose between "seeing themselves as incompetent and seeing
their prophets as false” (Lortie, 1975, p. 69). When faced with this dilemma, Lortie (1975) contends that practicing teachers “apparently lean toward choosing the latter” (p. 69).

**Research on Teacher Educators**

Teacher educators are influenced by the context in which they work including societal, institutional, programmatic, and student-related issues. These issues could be said to characterize aspects of the terrain surrounding a teacher educator—a sort of explorer. Additionally, explorers’ rates of progress over various terrains are attributable to characteristics of the explorers themselves. For instance, an explorer’s physical stamina and sheer determination influence one’s rate of progress when hiking over a mountain pass. Similarly, characteristics of teacher educators, such as how they view their role and their preparation for various job responsibilities, influence one’s efforts as a teacher educator.

**Questions of Identity**

The term “teacher educator” causes confusion when considering the persons to whom this definition could apply. Given that preservice teachers typically take coursework in pedagogy, liberal arts and sciences and specialized subject matter pertinent to a major of study, the term “teacher educator” denotatively refers to all persons who teach these courses. However, “most professors in the arts and sciences
are perceived, neither by others or by themselves, as teacher educators” (Lanier & Little, 1986, p. 529). One connotative meaning of the term refers to professors teaching coursework in pedagogy, except that only about one-fifth of a secondary preservice teacher’s required program and one-third of an elementary preservice teacher’s program is represented using this meaning. A second connotative meaning could include any professor who is part of a unit with “education” in its title, yet many faculty members in these departments do not teach teachers. The students they teach are pursuing interests in alternative, school-related capacities, such as administration, technology specialists, curriculum specialists, library specialists, counseling, school psychology, or researchers on schools.

When professors of education who teach foundational coursework in an education department are asked to identify their role in teacher education, they identify primarily with their discipline (e.g., cognitive psychology, philosophy of education). Lanier and Little (1986) report that these professors tend to deny their teacher education role and identify those who teach methods courses and supervise practice teaching as the real teacher educators. However, most professors teaching methods courses disagree. Professors teaching methods tend to identify themselves with the school subjects of their expertise, identifying themselves as specialists, such as science educators or math educators. Persons who supervise fieldwork are
probably the only faculty, as a group, who publicly identify themselves as teacher educators. This confusion over identity is second in importance to the choices faculty members make in terms of their professional pursuits. Borrowman (1965) claims that faculty in institutions preparing 90% of the teachers in America “have an interest in teacher education that is, at best, tangential to their most active concerns” (p. 39).

Information on the Current Professoriate

Information is available profiling current professors of teacher education by ethnicity, gender, rank, age, faculty roles and responsibilities, and work load (Zimpher & Sherrill, 1996). The current professoriate is mainly and consistently Anglo, with gender varying considerably depending on the population surveyed (i.e., urban schools are 55-60% female, compared to 28-30% female in secondary and humanistic foundations). In terms of gender and ethnicity, Ducharme and Cluender (1990, as cited in Zimpher & Sherrill, 1996) project that “the overwhelming ‘maleness’ of the faculty is likely to decrease, but the ‘whiteness’ will continue to grow” (p. 284). Overall, the percentage of tenured faculty in the education professoriate was relatively constant over the years at 65% to 75% with notable evidence of a shift in the profile of women in various ranked positions.
Changes in promotion standards have not made it easier for faculty and deans to be promoted in rank. The faculty age on average (late forties-early fifties) hovers very near an all-university average (47 years of age). Zimpher and Sherrill (1996) consulted two different studies and noted contrasting results in terms of faculty roles and responsibilities. Studies by the American Association of Colleges for Teacher Education (AACTE)--Research Affecting Teacher Education (RATE) studies--reported that more than 80% of faculty had prior experience teaching (K-12), but Goodlad (1990a) reported only 27% of faculty had elementary experience and only 18% report experience at the secondary level. Faculty divide their time weekly across responsibilities involving preparation for class, teaching undergraduates, research, administration, advising, committees, teaching graduate students, and in-service activities.

Goodlad (1990a) asserts that, as scholarly work has risen in preeminence, a shift has occurred in the balance of institutional missions at the expense of teaching and service. Thus, when faculty themselves are asked to describe their role, they are generally reluctant to identify themselves as teacher educators even when heavily involved in teacher education. This fact is likely not attributable to one aspect alone. There may be a problem with properly defining who exactly is identified as a teacher educator. There may also be a problem of poor reputation and status issues
within society as mentioned previously. When questioned about their career satisfaction and conceptions about themselves, teacher educators tend to be quite satisfied with their careers; however, the issue of "second-ratedness" as professors of education, perceived or otherwise, is a contentious point.

Various researchers have set forth to account for differences in the academic lives of teacher educators compared to other faculty. Prichard, Fen, and Buxton (1971) noted that most college teachers of education were from lower social class backgrounds that may impress conformist orientations characterized by a lack of probing thought and analysis and utilitarian views of knowledge on teacher educators. Ducharme and Agne (1982) found that most college education faculty enter institutions of higher learning later after having held a teaching and/or an administrative position in a K-12 setting and, thus, tend to be older than colleagues of equal rank in other departments. A large number of faculty in institutions that prepare teachers work with K-12 personnel in a programmatic framework "which requires getting the job done more than it does the pursuit of theory" (Lanier & Little, 1986, p. 531). Not surprisingly, then, when Guba and Clark (1978) compared the scholarly productivity of faculty in education to others on a per-faculty-member basis, even in the doctoral-level schools, colleges, and departments of education, the productivity norm was basically "non-productivity" (p. 8).
Many different programs, such as medical programs, have clinical experiences, but, whereas medical schools hire clinical faculty to oversee the experiences, clinical faculty are not hired in teacher education; teacher educators are often tasked to oversee clinical experiences as well. Additionally, Ducharme and Agne (1982) also asked faculty in education why they took the positions that they currently occupy, faculty described reasons that had very little to with research interests. Instead, they reported being motivated to take positions as faculty in order to have an indirect impact on the places from which they came—"the lower schools" (Ducharme & Agne, 1982, p. 34).

According to Lanier and Little (1986), at the time of publication, the size of the body of literature focused on better understanding teacher educators is modest. To date, no striking additions have been made to this body. While it is certainly important to consider what is described in a body of literature, an equally important consideration is an examination of what is not reportedly known about teacher educators. Notably, existing information intended to promote a better understanding of teacher educators is focused primarily on demographic information and the dynamics of working as a faculty member in a university setting. No mention is made in literature of how teacher educators develop, how they act in practice, how they think, or how to best prepare a teacher educator.
The Preparation of Teacher Educators

The literature described previously pertaining to teacher educators in general applies to specific groups of teacher educators as well, such as science teacher educators. Given that the data set for this research effort focuses on science teacher educators, the discussion will narrow slightly at this point; however, much of the preparation described for science teacher educators is likely applicable to other subject-specific areas as well.

With regard to the preparation of science teacher educators, the Association for Science Teacher Education (ASTE), formerly known as the Association for the Education of Teachers in Science (AETS), put forward a framework by Lederman, Kuerbis, Loving, Ramey-Gassert, Roychoudhury and Spector (1997) to define more clearly the expertise needed by qualified science teacher educators. The framework consists of six standards, which clearly define the "knowledge, skills, experiences, attitudes and habits of mind essential for the successful science teacher educator" (p. 233). The six standards include knowledge of science; science pedagogy; curriculum, instruction, and assessment; knowledge of learning and cognition; research/scholarly activity; and professional development activities. The authors envisioned that this list of standards would not be considered as an absolute prescription, but rather would fulfill a number of purposes: (1) provide significant
guidance for the development and revision of graduate level programs that prepare science teacher educators; (2) provide criteria for the qualifications of a university level science educator, and (3) provide guidelines for the qualifications of individuals conducting staff development projects, institutes, and workshops. However, in a postscript, Lederman et al. (1997) describe an important qualifier: "The standards are more than a checklist of skills, knowledge, and experiences to be achieved, and simply possessing them will not automatically transform an individual into a professional science teacher educator" (p. 240). This is because, "A difference in perspective exists between the experienced scientist or science teacher and the professional science teacher educator" (Lederman et al., 1997, p. 240). Thus, important questions remain unanswered in science education literature: How are science teacher educators prepared for their role in view of the previously mentioned standards?

One example is a mentoring program originating at the University of Iowa under the direction of John Penick, designed to purposefully prepare science teacher educators for the responsibilities they will undertake when teaching science methods (Craven, 1998). The program has three phases. In the first phase, the preservice science teacher educator (PSTE) observes a science methods course for preservice teachers and participates in the course as the preservice teachers are
expected to do. The PSTE completes all course requirements as if they were a preservice teacher, but additionally, they meet with the mentor teaching the course to discuss matters related to teaching preservice teachers, such as evaluation of the needs of preservice science teachers, relevant research, literature and teaching strategies used by the mentor, and types of questions raised by preservice teachers. Further, the PSTE is questioned by the mentor to assess and encourage deeper understandings related to pedagogy, curriculum, and approaches to teaching and learning. No mention is made of the kinds of questions that are most important in order to move the PSTE toward deeper understanding. PSTEs also observe the end-of-course requirement that the preservice teachers must complete—an oral defense.

Craven (1998) describes that “if it can be said that the process is a difficult one for the student, it can also be said that the process requires special skills and understandings on the part of the interviewer.” PSTEs are mentored regarding how to conduct oral defenses as they are mentored in the course—observe the process, meet with the mentor and discuss the PSTE’s perceptions of the process including identification of the types of questions that are particularly fruitful in eliciting a student’s understandings and/or misconceptions. In the second phase, the PSTE observes the preservice teachers in the field and notes how the mentor evaluates the preservice teacher during instruction and provides careful feedback to the
preservice teacher during a particularly vulnerable time. In the third phase, the PSTE becomes a co-instructor in the methods course during a subsequent semester and, at the same time, continues to maintain dialogue with the mentor. Success of the University of Iowa program is evident in the number of persons exiting the program who have since been honored with awards in science teacher education; however, to date, this program nor any other program related to the preservice education of science teacher educators has been researched systematically and thoroughly (Windschitl, 2005).

In an effort to spawn reform in teacher education, Fullan (1993) created a list of attributes that he believes the “best faculty” should display. One attribute he listed relates directly to the practices modeled by teacher educators. Specifically, the “best faculty” should value and practice exemplary teaching. Similarly, Goodlad (1990a) created a list of conditions necessary for effective teacher education and included the following postulate: “Programs for the education of educators must be characterized in all respects by the conditions for learning that future teachers are to establish in their own schools and classrooms” (p. 59). In short, Goodlad (1990a) asserts that it is indefensible for teacher education programs not to be exemplary models of the practices that they advocate.
Anderson (1997) equates reforming instruction by a teacher educator in a methods course with instigating school reform. A science methods instructor who is rethinking his or her practices faces challenges similar to a secondary chemistry teacher who is reforming his or her course to make it more consistent with the National Science Education Standards (NRC, 1996). In other words, “change is never easy” and, any time one initiates change, “dilemmas are inevitable” (Anderson, 1997, p. 278). Anderson (1997) suggests four actions from research on educational reform be considered when trying to instigate instructional reform: (1) reading literature on educational reform and reflecting on implications for one’s personal instruction; (2) writing journal reflections on one’s teaching; (3) collaborating with other methods instructors in other subject areas and sharing, observing and discussing each other’s dilemmas; and (4) initiating new practices with respect to students’ work and roles and critically examining the results using the students’ help. While these suggestions stem from research in other contexts, Anderson (1997) argues that conclusions from research in improving science instruction in schools can be applied to preservice teacher education.

Very little research, however, exists to inform the science education community about how to reform the practices of science teacher educators in methods coursework (Anderson & Mitchener, 1994; Lanier & Little, 1986;
Windschitl, 2005). Lanier and Little (1986) argue that this lack of research stands in stark contrast to research on teaching youngsters: “When teaching is studied in elementary and secondary schools, teachers are considered too important to overlook. But teachers of teachers--what they are like, what they do, what they think--are typically overlooked in studies of teacher education” (p. 528).

A small number of publications in the literature (e.g., Cautreels, 2003, LaBoskey, 1997) make suggestions regarding how teacher educators might teach more effectively; however, these publications are conceptual pieces rather than research studies. One exception is a study that examined the role of beliefs, reflection, and inquiry as a teaching methodology in a secondary science methods course and the impact of such instruction on preservice teachers in the methods course under study as they began their practice (Foley, 2004). Reported results in this study support using inquiry-based teaching methods, exploring individual belief systems and frameworks during teacher preparation, and placing additional emphasis on the role of reflection in teacher preparation. Thus, very little research exists on reforming the practices of science teacher educators in methods coursework, and even less exists regarding how to design effective preservice education for science teacher educators themselves. Lanier and Little (1986) argue that
literature suggests that finding and keeping academically strong and committed teachers of teaching is possibly even more problematic than finding and keeping qualified students of teaching. Why this problem endures and yet receives such little research interest deserves consideration (p. 528).

Hence, the explorer—the teacher educator—is worthy of study in an effort to better understand how one acts and what one thinks while exploring the terrain associated with the field of teacher education.
CHAPTER 3: METHODS

Introduction

Preservice teachers and the science teacher educators who instruct them often possess differing views of teaching and learning. Preservice teachers, students themselves who have experienced instruction at multiple levels from kindergarten to the college, often perceive teaching as the “living out” of prior conceptions of “good” teaching (Lortie, 1975). As preservice teachers and science teacher educators encounter one another as students and teachers, they may easily talk past one another. The inherent challenges associated with these dilemmas fuel constancy rather than reform in teacher education and the field of education overall (Cuban, 1984). While researchers have begun exploring preservice teachers’ thinking as it relates to their practice, little is known about how science teacher educators think and what they do when they attempt to interact with preservice teachers to create situations in methods courses where meaningful learning occurs (Lanier & Little, 1986).

This study explored the development of three science teacher educators as they interacted with preservice teachers and sought to align their practices with what they advocated in the methods courses that they instructed. If science teacher educators have an identifiable growth process or identifiable dilemmas that must be
addressed as they strive to become more competent, perhaps experiences that aid in preparing science teacher educators can be designed to promote their growth. Thus, this research is intended to provide a valuable tool to the field of science teacher education to facilitate the preparation of science teacher educators who will design and teach methods courses.

**Research Questions**

Two research questions guided this study:

1. In what ways do science teacher educators' practices change over time as they conduct oral defenses with students in a methods course?

2. How closely do science teacher educators conduct oral defenses in methods courses in ways that are consistent with advocated practices?

**Design of the Study**

This study is a naturalistic inquiry of the development of three teacher educators over the course of semesters when they conducted oral defenses in the context of their science methods courses. Given that little preexisting knowledge has been put forth in literature on the development of science teacher educators (Foley, 2004), this study was considered exploratory and best conducted using a qualitative research design (Stern, 1980; Yin, 2003). The term "qualitative research" in the context of this study refers to a "nonmathematical process of interpretation, carried
out for the purpose of discovering concepts and relationships in raw data and then
organizing these into a theoretical explanatory scheme” (Strauss & Corbin, 1998, p. 11). One approach to doing qualitative research is grounded theory, defined as an
approach where ideas are derived from systematically gathering and analyzing data
throughout the research process (Strauss & Corbin, 1998). In other words, data
collection, analysis, and eventual presentation of theoretical ideas stand in close
relationship to one another; hence, the term, “grounded theory.” Assuming that the
development of science teacher educators is a process rather than an outcome, use of
a grounded theory approach serves to offer insight and provide a meaningful guide
to action regarding how to more effectively facilitate the process of preparing
science teacher educators to teach (Merriam, 2002; Strauss & Corbin, 1998).

**Context of the Study**

This section addresses specific aspects of the science methods courses selected
for this study. Descriptions of the model that was utilized to organize the course, use
of oral defenses as a final evaluation in the course, and practices that the instructors
advocated and intended to model in their teaching are presented.

**A Research-based Framework**

All participants in the study taught an elementary science methods course of
similar design that utilized a model called a research-based framework (RBF) for
teaching. An RBF has been implemented in different ways for several decades in
topservice science teacher education (Clough, 2003a, 2003b; Clough & Kauffman,
1999; Olson, 2003a, 2003b; Olson, in press; Penick, 1988, 2000; Penick & Yager, 1988;
Veronesi & Varrella, 1999). Elements of a research-based framework for teaching
include, but are not limited to the following:

- teacher, student, and societal goals for science education
- why science should be taught
- what science must be learned
- the nature of science
- how to facilitate learning in science in a manner consistent with what is
  known about students, learning, and science
- the nature of learners of all ages
- how to personally assess, evaluate, and change classroom climates and
  strategies to achieve progress toward stated goals.

(Penick & Yager, 1988)

Clough and Kauffman (1999) published a schematic that visually assists in
conceptualizing components of an RBF and the interconnectedness of these
components. While a more recent version of this schematic is now available in the
literature, the version that assists most in conceptualizing the context for this study
is the iteration (see Figure 1) that was distributed to the methods students enrolled
in the courses selected for study.
Throughout the semester, the methods students were advised to attend carefully to what is and is not meant by an RBF. The RBF was not to be viewed as a mechanistic prescription that teachers can employ to ensure effectiveness. Instead, an RBF was to be viewed as a decision-making model for use by teachers when planning, implementing, and reflecting upon instruction.

Utilization of an RBF design occurred on two levels in the methods courses selected for this study. First, students in the methods courses were challenged...
throughout the semester to synthesize their own RBF. Near the completion of the course, they represented their ideas in the form of a written paper and in an oral defense (a 90 minute interview) that served as the final evaluation for the course.

Second, throughout the methods course, the science teacher educators repeatedly claimed that the course should be a model of itself. Communication of this claim was frequent and was documented in multiple ways. For instance, the following excerpt comes from the course syllabi distributed to all methods students in the courses selected for this study. The syllabi excerpt reads as follows:

This course is intended to be a reflection of research on effective teaching congruent with consensus perspectives on human learning and goals for science education. If you sense discrepancies, you are expected to respectfully ask, “What is your rationale for....?”

In other words, as students were challenged to synthesize their own RBF, the instructors were challenged concurrently to model implementation of an RBF that aligns with what the students were working to synthesize.

**Oral Defenses as Used in this Study**

An oral defense serves as the capstone experience in various academic settings including science content courses as well as science methods courses utilizing an RBF design (Clough, 2003a, 2003b; Olson, 2003a, 2003b, in press; Penick, 2000). Terms also referring to an oral defense include “exit interview” or “oral exam.” The term that was most frequently used in the science methods courses
selected for this study was the term "oral defense"; thus, this is the term that will be used here.

To conceptualize better the challenges presented to the science teacher educators conducting oral defenses in this study, discussion of the nature of and rationale for the use of an oral defense is warranted. The oral defenses conducted in this study were of equal length and design. All interviews were 90 minutes in length. The first 60-70 minutes consisted of the student (preservice teacher) and teacher (science teacher educator) in discussion together. This discussion was initiated by a question from the teacher. The students would respond to the initiatory question that was posed and then, based upon the students' responses, the teacher directed subsequent discussion as deemed most beneficial. This time of discussion offered the teacher educator an opportunity to probe students' thinking in an effort to better grasp their understanding of the topics in question and to create situations where learning was promoted by helping students make connections. Given the inherent nature of conversation itself, deftly interviewing students as compared to posing similar questions on a written exam offers more flexibility allowing an interviewer to probe knowledge areas when vague, limited and/or conflicting responses are given (Posner & Gertzog, 1982). Notably, this flexibility is not possible when using a written assessment that is constrained by an inability to
ask additional probing questions based on students' initial responses to questions.

The choice to conduct oral defenses with students is, in part, an effort to make the methods course a reflection of itself; a course where student thinking is valued and instructors are challenged to make decisions in their teaching that are based on students' prior knowledge and current thinking. During the last 20-30 minutes of each oral defense, students practiced their ability to self-assess. Under the instructor's guidance, the students were challenged to identify the grade that best represented their understanding and performance in the course and justify their decision using pertinent evidence and criteria from the course syllabus.

Conducting oral defenses effectively with science methods students presents numerous cognitive challenges for the interviewer (methods instructor). First, a well-constructed interview begins with careful phrasing of questions so as not to cue a particular response, but to stimulate students' thinking and invite them to look more closely at a situation (Clough & Berg, 1995). This kind of questioning is consistent with research on effective teaching, where "a good question" is described as "an invitation to a closer look" and/or "a problem to be solved" (Elstgeest, 1985, p. 37). After asking an initiatory question, the interviewer must listen carefully to the student's response in an effort to fathom how a student conceptualizes various ideas and the reasoning that the students have put together in their minds as they have
made sense of their experiences. After the student responds to an initial question, the interviewer has opportunity to ask follow-up questions that can serve three important purposes:

1. Probing questions give the interviewer an opportunity to further investigate students’ understanding which promotes more accurately diagnosing students’ thinking.

2. Follow-up questions provide feedback to the students as to the degree of accuracy, completeness and credibility of their previous responses.

3. After careful diagnosis of students’ thinking, additional follow-up questions promote learning by helping students make new connections.

These three purposes are different, but equally important and resonate with what Shulman (2000) calls the essence of pedagogy: “putting the inside out; working on it together while it is out, then putting the outside back in” (p. 133).

**Advocated Practices in the Methods Courses Selected for this Study**

The oral defenses that were conducted in the science methods courses selected for this study provide a window through which to view how the science teacher educators (participants) implemented practices that they advocated during their instruction. Practices advocated by the methods instructors were consistent with research-based teaching practices and goals of the science education
community. These practices included intentionally promoting student goals, such as critical thinking and communicating effectively; working to assist students to see the errors in their thinking; carefully choosing when to explain ideas to students; promoting self-assessment practices; and carefully attending students to the teacher's role. In the context of the methods courses selected for this study, the phrase, "the teacher's role" refers specifically to implementation of the central core of effective teaching that teachers always have at their disposal (Clough, 2003b).

Specifically, the central core of effective teaching consists of using multiple teacher behaviors, including using intellectually engaging, extended-answer questions to elicit student thinking and create learning opportunities (Blosser, 1991; Elstgeest, 1985; Good & Brophy, 1994; Olson & Clough, 2004; Penick, Crow, & Bonnstetter, 1996; Shymansky & Penick, 1981), employing wait time I and II (Rowe, 1974a, 1974b, 1986), listening attentively to students, displaying encouraging nonverbal behaviors, such as smiling, proper eye contact, and raised eyebrows (Chory & McCroskey, 1999; Neill & Caswell, 1993), and responding sensitively to students' answers (e.g., acknowledging students' ideas by writing their responses in a prominent location, basing follow-up questions on students' ideas). Implementation of the essential core of effective teaching was the linchpin that further promoted
implementation of all of the practices advocated in the course, such as assisting students in recognizing errors in their thinking and promoting self-assessment.

**Selection of the Participants**

The participants for this study were three teacher educators who taught science methods coursework at a large land-grant university in the Midwest region of the United States. They were selectively sampled based on certain general considerations. To accurately interpret the similarities and differences amongst the three participants, a discussion of the general criteria for selecting the participants is necessary. Next, a detailed description of each participant is provided.

General considerations that were used to sample participants selectively included accounting for differences in the types of students who were interviewed by the participants in oral defenses and consideration of the teaching experience of potential participants in both methods coursework and science classes. All selected participants were teaching students who were similar in terms of academic progress. Given that an interviewer's decision-making can be influenced heavily by interviewees' responses, observations were made with students of similar academic experience. All who were interviewed by the participants had enrolled in a science methods course during their junior or senior year as elementary education majors. Most of the students were in their final semester of coursework prior to student
teaching. The students altogether were predominantly female, Caucasian, 21-24 years of age, and natives of the Midwestern United States. All participants had to have had multiple opportunities to conduct oral defenses over time. Given that the average enrollment in one section of a methods course under study is 25-26 students, any participant who had taught for at least one semester had multiple experiences with conducting exit interviews. In order to more completely observe the development of any participant over time, participants were selected if they had a minimum of four semesters of experience teaching science methods to elementary education majors. All participants had to have previous science teaching experience at the K-12 level, given the findings of Ashmann, Gallagher, and Gwekwerere (2004) whereby over half of the job postings from 2001 to 2002 in science teacher education in the U.S. set forth this job requirement.

Description of the Participants

Three participants were identified using selective sampling.

Joanne, the first participant, has taught multiple content areas (science content, math content, methods courses for teacher education programs, and supervision of student teachers) at multiple levels (elementary, middle school, and university) over the course of ten years. She has authored several articles, given numerous presentations regarding effective science teaching, and has received
recognition at the local and national level for her teaching practice. Throughout the time in which data was collected for this study, Joanne taught a total of nine sections of elementary science methods. In seven of the nine sections, Joanne conducted oral defenses with her students as a final assessment in the course. Joanne's decision-making in these seven sections was examined in this study. Prior to teaching her first of these seven sections, Joanne had not conducted any oral defenses.

Joanne received mentoring from a colleague in secondary science education regarding how to effectively conduct oral defenses. First, during this mentorship, Joanne was given a set of initiatory questions which had been used by her colleague when conducting oral defenses with secondary education majors. These questions are listed below:

- How would you define learning?
- How will you decide what content to teach? materials to use? activities to implement?
- Select one of your student goals, defend the inclusion of this goal and how you facilitate it.
- Select a student goal for the intern and have them do the above.
- How would you define teaching?
- What does being a student-centered teacher mean? What would this look like as opposed to being a teacher-centered teacher?
- How can you make students feel uncomfortable and comfortable at the same time?
- Of what importance is a clear articulation of your RBF?
- What advice would you provide a novice teacher on how to run a successful discussion?
- In what areas in your RBF do you most need to grow? What are your strategies for improving?
• How will you assess your students' progress?
• How would you justify answering a students' question with another question if challenged by a skeptical parent or administrator?
• What importance does a non-evaluative atmosphere have for promoting self-evaluation?
• How will you teach your students so they become more confident?
• How will you know if you are a successful teacher?
• How do you teach Mendelian genetics in a student-centered manner?
• What evidence do you have that your verbal explanations will result in student understanding?
• What perception is conveyed by your not including ____ in your RBF paper?
• What evidence can you provide for ____?
• How much time did we spend on ____ in class?

Second, Joanne and her colleague watched a videotape together of the colleague conducting an oral defense with a student in secondary science education. As they watched the videotape together, they stopped the videotape periodically and discussed how her colleague used the initiatory and probing questions and his rationale for doing so. In total, Joanne conducted 185 oral defenses with methods students in the courses selected for study. The highest degree Joanne had earned at the time of this study is a doctoral degree.

The second participant, Andrea, is like Joanne in that she has taught various subject areas and supervised student teachers; however, her science teaching experience is in the areas of chemistry and biology at the secondary level only. At the time of the study, she had two years of science teaching experience and two and a half years experience teaching education coursework. Throughout the course of
this study, Andrea taught a total of six sections of elementary science methods, five of which involved conducting oral defenses. Andrea’s preparation for conducting oral defenses differed slightly from Joanne’s preparation. In this case, Joanne mentored Andrea. The mentoring Andrea received occurred one full semester prior to when she began teaching science methods and conducting oral defenses herself. To begin, Joanne gave Andrea the same list of questions she had been given and then, with the students’ permission, Andrea observed Joanne conduct five oral defenses with elementary methods students. A time of debriefing (approximately 15 minutes) followed each observation where Andrea and Joanne discussed certain moves Joanne had made and her rationale for doing so. In total, Andrea conducted 121 oral defenses with elementary science methods students over the course of the semesters under study here. The highest degree Andrea had earned at the time of this study is a master’s degree.

In an effort to respect the participants’ potential desire for anonymity, the researcher asked each participant to provide a preferred pseudonym. Joanne indicated that she would rather not have a pseudonym and asked to be referred to by her first name. Joanne explained that she felt changing her name would alter how she was perceived in some way by readers of this study and, thus, she found it difficult to consider identifying herself using a pseudonym. Andrea gave permission
for her first name to be used as well. Both candidates signed consent forms making special note of this unusual research practice.

The third participant, Crystal, is not only a participant in this study, but also is the primary researcher. I am a former science teacher who has science teaching experience at the secondary, post-secondary and university levels over the course of twelve years. At all levels, I taught chemistry. During the time in which data was collected for this study, I taught 5 sections of elementary science methods; 4 of the 5 sections utilized oral defenses. My preparation for conducting oral defenses was nearly identical to Andrea’s preparation. I was mentored by Joanne as well. Unlike Andrea who was mentored before she began teaching methods, my mentoring occurred during the same semester in which I began teaching methods for the first time. I received materials from Joanne and Andrea, but I utilized mainly what Joanne gave me. I observed Joanne conducting four oral defenses and de-briefed with her after each observation. In total, I conducted 99 oral defenses with elementary science methods students over the course of the semesters under study in this case. The highest degree I had earned at the time of this study was a master’s degree.

The order in which data were selected to be analyzed in this study was carefully determined. In short, the order of analysis was based on the participants’
experience conducting oral defenses. Joanne had conducted the most oral defenses over the course of the most semesters. Thus, Joanne's data set was analyzed first. Andrea's data set was analyzed second using what had been observed previously. After analyzing both Andrea and Joanne's data sets separately, then I proceeded to analyze my own data set using previous interpretations made from observing Andrea and Joanne's decision-making. This order of analysis with my own data set analyzed last offered a unique research opportunity. The ultimate purpose of this study is to build a theoretical framework that describes the process of development by a set of science teacher educators when conducting oral defenses.

Ultimately, once a theoretical framework is developed, the expectation is that such a framework could be used to evaluate and improve the teaching practices of other teacher educators, particularly those who are less experienced. In my case, I used the theoretical framework I had designed based on Joanne's and Andrea's data sets to evaluate my own practice. In a sense, one could say that I had opportunity to pilot the theoretical framework that I developed using data from my own practice. Towards this end, I was benefited in two ways; as a researcher and as a less experienced science teacher educator.

Notably, all three participants were enthusiastic about conducting oral defenses as the strategy is designed to be used--as both a diagnostic tool and as an
opportunity to create situations where meaningful student learning is more likely to occur.

**Data Collection**

The primary data source in this study was audiotapes of the participants conducting oral defenses with elementary preservice teachers in methods courses of similar design. Data from oral defenses were selected as the primary data source for several reasons. First, an exit interview is a microcosm of teaching in a larger classroom setting. Clough writes, “teaching is above all else an activity centered on human interaction” where “one of the most complex and unpredictable portions of teaching is interacting with students to better understand their thinking and help them create intended meanings” (Clough, 2003b, p. 15). This sort of interaction can occur in large groups and small groups, even groups as small as two members. Thus, one’s ability to conduct oral defenses was assumed to be a microcosmic view of interaction patterns between teachers and students in a somewhat idealized setting. The oral defense is considered an idealized setting because, while the interaction patterns of teachers are no different from those expected in a larger classroom, the setting of an oral defense removes some of the complexities inherent in a larger classroom. In an oral defense where a teacher is interacting with one student for an extended time, a teacher does not experience distractions that are
common in a classroom setting, such as classroom management concerns and performing administrative tasks (e.g., taking attendance, returning papers to students) that conspire to thwart a teacher’s efforts when trying to create learning experiences through interaction with students. If a teacher educator cannot expertly conduct an oral defense with one student, then one’s ability to create opportunities for meaningful learning through discussion in a larger classroom setting is doubtful.

Purposeful sampling of the audiotapes occurred based on several criteria. First, the intent was to examine each participant longitudinally as she conducted oral defenses. Thus, audiotapes were selected from a series of semesters within the regular academic year. Second, analysis of the data over time warrants devising criteria for selecting audiotapes per semester. Information from the pilot study assisted in shaping a set of criteria for making selections of audiotapes for each semester under study. Criteria for selecting audiotapes per semester were as follows:

1. Given that all oral defenses in a methods class had to be completed in the last two weeks of a semester per university guidelines, participants acknowledged having to conduct five or six interviews in a day to ensure that all methods students completed course requirements on schedule. While participants felt comfortable conducting four interviews per day, they admitted feeling exhausted when conducting more than this number. Thus, when it is known that an audiotape was
the fifth or sixth interview conducted by a participant in one day, these audiotapes were replaced by the next available audiotape. (2) Participants claimed that no matter how many exit interviews they had conducted in previous semesters, they always had to reacquaint themselves each semester with the cognitive challenges inherent in conducting oral defenses. Thus, the first three oral defenses in each semester for all participants were not selected for analysis. Similarly, the participants claimed that they grew weary after conducting approximately twenty interviews. Thus, when possible, the audiotapes selected were not the earliest nor the latest interviews conducted in a semester per participant. (3) One could argue that the academic abilities of the students in each interview could also contribute to altering the interviewers' experience. Thus, the researcher maintained a similar grade distribution among students in the audiotapes selected for each participant. (4) Audiotapes were to be analyzed in sets of two to better ensure an accurate representation of what was occurring at a particular time. Altogether, the scheme for selecting audiotapes for each participant per semester was as follows: Set 1: Tapes 4 and 5, Set 2: Tapes 10 and 11, and Set 3: Tapes 16 and 17. A caveat was added to this criterion in that if data saturation did not occur after selecting audiotapes in this manner, then the set of selected audiotapes was expanded as needed using the next available audiotape until data saturation occurred.
All oral defenses were transcribed verbatim to assist in the process of data analysis. During the process of transcribing, careful attention was paid to pausing, rephrasing questions, and other verbal cues to assist in better understanding the flow of dialogue between the participants and students.

**Data Analysis**

Data analysis was conducted to explore how the participants processed and responded to learning opportunities encountered in oral defenses with preservice teachers who were enrolled in elementary science methods. Data were analyzed through a constant comparative method of analysis (Glaser & Strauss, 1967). Analysis involved developing a coding scheme, coding data from all three participants and developing visual displays of data derived from the coding process.

Analysis of data early in the study established two potentially fruitful areas of analysis: the participants' use of explanation and their use of probing questions. These two areas--explanation and use of probing questions--were called major categories. Open coding occurred throughout the development of a coding scheme to establish sub-categories within each major category that described the participants' use of explanation as well as the participants' use of probing questions, respectively. After identifying any new sub-category, a description of the sub-category was written including at least one exemplar verbatim from an oral defense
transcript that aligned with the code description. Axial coding was then conducted to develop and link subcategories systematically within the two major categories, respectively, to better describe how behaviors exhibited by a participant were similar or different in kind and sophistication.

Degree of sophistication was based primarily on evidence of student learning in the transcript and consistency with research regarding effective teaching. The hierarchical arrangement of the sub-categories in order of sophistication was validated by Joanne, a more experienced science teacher educator.

After developing a coding scheme, data sets for each participant were coded in a carefully selected order. The order of analysis was based on overall experience conducting oral defenses. Thus, Joanne’s data set was analyzed first because she was the most experienced interviewer overall followed by Andrea’s data set and then Crystal’s data set. Within each data set, the oral defense transcripts were organized and coded beginning with the interview when each participant was least experienced through when she was most experienced.

To ensure consistency in the coding process, deliberate strategies were followed. Lists of quotations pertaining to specific sub-categories were generated and scanned periodically for consistency. When the initial coding process was complete, select sub-categories were rechecked for consistency. Sub-categories that
were selected were those that were particularly problematic to distinguish during the coding process and/or those that were most frequently coded. To triangulate decisions made in the coding process, the researcher asked the other two participants, Joanne and Andrea, to use the proposed coding scheme to code excerpts of interview transcripts for all three participants. Feedback from this process was used to refine the code descriptions/exemplars and to collapse similar sub-categories or create new ones where notable distinctions warranted careful designation. Inter-rater reliability was calculated to evaluate consistency overall in the coding process. A software program called ATLAS.ti, Version 5.0, designed specifically for the purpose of qualitatively analyzing large bodies of textual data, was used to assist in organizing the coding process.

While analyzing transcripts, changes in the participants’ interaction patterns when explaining or asking probing questions were noted carefully. Upon completing analysis of audiotapes for each semester under study, a summary of observations was written in the form of a research memo.

After completing the coding process, visual displays of data derived from the coding process were developed. First, tables were constructed to list the frequency of each code per semester per participant. Certain codes were grouped according to sophistication and frequency totals per grouping were calculated for each
participant. Second, frequency totals per semester were graphed for each participant to provide a visual representation of any changes in a participants' decision-making across semesters. Comparisons across the participants were conducted visually by overlaying the graphs that had previously been constructed for each participant. Third, profiles were constructed of select interviews for each participant to visually display an interviewer's decision-making in different semesters of experience. Fourth, patterns in the participants' decision-making were noted both within and across the participants. Member checks were conducted with Joanne and Andrea to substantiate findings. The research memos that were previously described and member checks with the participants were used to ensure credibility of the resulting interpretations regarding developmental changes in the participants' practices over the course of the semesters under study (Esterberg, 2002).

Assumptions, Limitations, and Delimitations

Assumptions in this study relate mainly to the participants under study and the usefulness of analyzing decision-making in an oral defense setting. First, the participants in the study are assumed to be motivated to improve their practice for the main purpose of improving science instruction for students in today's schools. Second, the participants were assumed to not have any medical, emotional, and/or psychological conditions that might interfere with their abilities to teach. Third, use
of a participant as both the primary researcher and a participant introduces bias in
the research process that must be acknowledged. As both a researcher and a
participant, I could easily overassess or underassess my practice. However, steps in
the research process were taken carefully to account for such researcher bias. I
carefully ordered how I chose to analyze the data from all three participants and
chose to analyze my own data set last. Thus, my interpretations of my own practice
were made in view of my analyses of the other two participants' data. Further, when
addressing issues of reliability, all three participants coded behaviors from interview
transcripts including excerpts from each participant’s data set. Fourth, the oral
defense is assumed to be a microcosm of the larger classroom. Analysis of
instructional decision-making during an oral defense is assumed to be
representative of challenges encountered in larger classroom settings and, thus,
worthy of study.

Limitations in this study include the number of participants and the timing of
this study compared to when most oral defenses were recorded. Many of the
audiotapes were recorded less recently. A more ideal method for triangulating the
decision-making of the participants would have been to interview the participants or
have them write journal entries about their experiences conducting specific oral
defenses shortly after conducting an interview. However, this did not occur for all
participants in all semesters under study (a minimum of four semesters) and is acknowledged as a limitation of the study.

Delimitations related to this study include characteristics of the students in the oral defenses under study compared to characteristics of the selected participants. First, the audiotapes are recordings of students in a preservice elementary science methods course who are mainly ages 21-24, Caucasian, and female. Thus, any results and interpretations should be situated with these characteristics in mind. Second, all participants are educated females in science and, thus, a majority of the interactions that were analyzed were observed between a female teacher and a female student.

**Pilot Study**

A pilot study explored differences between the practices of two science teacher educators when interacting with methods students in oral defenses during two different time periods. The two time periods that were selected for study were the semesters when the participants were most and least experienced in terms of conducting oral defenses. The interaction that was observed occurred when the participants conducted oral defenses with preservice teachers as a culminating evaluation of the students' understanding and performance in a science methods course. The data set consisted of four oral defenses per semester per participant. The
oral defenses were selected in an effort to maintain a similar grade distribution amongst the students who were interviewed. All oral defenses were transcribed for analysis. A constant comparative method was used during data analysis. Preliminary findings for the pilot study indicated that the participants' practices were more expert-like when they had more experience conducting oral defenses. More specifically, the participants improved in their (1) abilities to diagnose students' thinking, (2) familiarity with patterns in students' responses, (3) ability to draw inferences and, (4) ability to construct sophisticated lines of questioning.
CHAPTER 4: RESULTS AND DISCUSSION

The Problem

Growing public concern about the quality of teaching in our nation's schools calls to question the effectiveness of the institution designed to prepare preservice teachers to teach capably. The effectiveness of teacher education as a whole inarguably reflects, in part, the effectiveness of the practices of teacher educators as they instruct courses that are part of college and university-based educational programs (Goodlad, 1990a). As the effectiveness of teacher education is called to question so, too, are the practices of teacher educators. However, in the field of teacher education, teacher educators--what they do in practice, how they think--is largely unreported in the literature (Lanier & Little, 1986). Typically, science teacher educators who teach various education courses are selected mainly on their education and experience in a classroom (typically grades K-12) teaching subject-specific content, such as a physical science or biology (Ashmann et al., 2004). While these qualifications are certainly important, very little research has been conducted and reported to substantiate that such preparation is sufficient. Additionally, the development of science teacher educators as they seek to align their practices with what they advocate in the courses that they teach is unstudied. Hence, this study
explores how the practices of three science teacher educators develop as they instruct science methods courses over the course of multiple semesters.

**Research Questions**

This study has two primary purposes. The first purpose is to determine how the participants' practices changed over the time they taught elementary science methods and utilized oral defenses as the culminating evaluation in the course. The second purpose evaluated the ways in which the participants practiced the very ideas that they advocated in the methods courses they taught. These purposes are addressed through two research questions:

1. In what ways do science teacher educators' practices change over time as they conduct oral defenses with students in a methods course?

2. How closely do science teacher educators conduct oral defenses in methods courses in ways that are consistent with advocated practices?

This chapter is organized into four main sections. The first section pertains to general information pertinent to both research questions and is necessary for better understanding the organization of subsequent sections. The second section describes the process of data analysis. The third and fourth sections focus on a discussion of the two research questions, respectively.
In preparation for data analysis, audiotapes from oral defenses involving each participant at various times in their practice were selected. Originally, a set of six oral defenses per semester was to be transcribed and analyzed for each participant. However, after transcribing data for one participant and partially doing so for a second participant, the total quantity of textual data for this study was projected to exceed nearly 1,000 pages of single-spaced text. In an effort to reduce the data set to a manageable, yet representative, sample, the data set was modified from selecting six to four audiotapes per semester. This change seemed reasonable based upon results from the pilot study, where four audiotapes were analyzed per semester and data saturation occurred. The four audiotapes were selected from three different times in the interviewing process per semester--near the beginning, midpoint and near the end of the interviewing process per semester. When possible, pairs of audiotapes were selected (e.g., tapes 5 and 6 were selected). Various technical difficulties in the recording process (e.g., student's voice was inaudible, battery failure) when the oral defenses were conducted (sometimes years ago) prohibited following this scheme exactly. When the pattern could not be followed exactly, the next closest audiotape was selected. A similar grade distribution of the students on the audiotapes per semester was maintained as much as possible.
Whenever possible, the order in which oral defenses were conducted per semester was noted. The designation, N/A, notes semesters when the order of interviews is not available. In total, 28 oral defenses were transcribed for one participant, Joanne, 20 oral defenses were transcribed for a second participant, Andrea, and 16 oral defenses were transcribed for a third participant, Crystal. Each transcribed oral defense was 90 minutes in length. All students in the oral defenses are referenced using pseudonyms. A summary of the audiotapes selected for each participant are shown in Tables 1, 2, and 3.
Table 1. Joanne’s oral defenses selected for analysis.

<table>
<thead>
<tr>
<th>Semesters of Experience</th>
<th>Academic Term</th>
<th>Interview Number per Semester</th>
<th>Student Name</th>
<th>Student's Course Grade</th>
<th>Grade Distribution Overall for Selected Audiotapes</th>
<th>Number of Oral Defenses per Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spring '00</td>
<td>N/A</td>
<td>Sarah J.</td>
<td>B</td>
<td>A, A-, B, B</td>
<td>19</td>
</tr>
<tr>
<td>1</td>
<td>Spring '00</td>
<td>N/A</td>
<td>Heather J.</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Spring '00</td>
<td>N/A</td>
<td>Ella L.</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Spring '00</td>
<td>N/A</td>
<td>Tim M.</td>
<td>A-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Fall '00</td>
<td>N/A</td>
<td>Beckv B.</td>
<td>B+</td>
<td>A-, A-, B+, B+</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>Fall '00</td>
<td>N/A</td>
<td>Allie A.</td>
<td>A-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Fall '00</td>
<td>N/A</td>
<td>Becca B.</td>
<td>B+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Fall '00</td>
<td>N/A</td>
<td>Kim K.</td>
<td>A-</td>
<td></td>
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<tr>
<td>3</td>
<td>Spring '01</td>
<td>5</td>
<td>Mary C.</td>
<td>A-</td>
<td>A, A-, B+, B+</td>
<td>52</td>
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<tr>
<td>3</td>
<td>Spring '01</td>
<td>6</td>
<td>Kel K.</td>
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</tr>
<tr>
<td>3</td>
<td>Spring '01</td>
<td>11</td>
<td>Jen J.</td>
<td>B+</td>
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</tr>
<tr>
<td>3</td>
<td>Spring '01</td>
<td>17</td>
<td>Jo J.</td>
<td>A</td>
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</tr>
<tr>
<td>4</td>
<td>Fall '01</td>
<td>6</td>
<td>Jan J.</td>
<td>B</td>
<td>B+, B, B, C+</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>Fall '01</td>
<td>10</td>
<td>Kevin C.</td>
<td>B+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Fall '01</td>
<td>16</td>
<td>Shelly S.</td>
<td>C+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Fall '01</td>
<td>17</td>
<td>Evan A.</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Fall '02</td>
<td>6</td>
<td>Karen J.</td>
<td>A-</td>
<td>A-, B+, B, B</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>Fall '02</td>
<td>10</td>
<td>Alicia S.</td>
<td>B</td>
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<tr>
<td>5</td>
<td>Fall '02</td>
<td>11</td>
<td>Nate S.</td>
<td>B</td>
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<tr>
<td>5</td>
<td>Fall '02</td>
<td>17</td>
<td>Lauren L.</td>
<td>B+</td>
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<tr>
<td>6</td>
<td>Spring '03</td>
<td>5</td>
<td>Maria J.</td>
<td>B+</td>
<td>A, B+, B, B</td>
<td>29</td>
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<tr>
<td>6</td>
<td>Spring '03</td>
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<td>Mel S.</td>
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<td></td>
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</tr>
<tr>
<td>6</td>
<td>Spring '03</td>
<td>16</td>
<td>Bess M.</td>
<td>B</td>
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</tr>
<tr>
<td>6</td>
<td>Spring '03</td>
<td>17</td>
<td>Christy A.</td>
<td>A</td>
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<tr>
<td>7</td>
<td>Spring '04</td>
<td>5</td>
<td>Jacob J.</td>
<td>B+</td>
<td>A, A-, B+, B</td>
<td>21</td>
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<tr>
<td>7</td>
<td>Spring '04</td>
<td>6</td>
<td>Larin L.</td>
<td>A-</td>
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<tr>
<td>7</td>
<td>Spring '04</td>
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<td>Bob R.</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Spring '04</td>
<td>16</td>
<td>Tia J.</td>
<td>A</td>
<td></td>
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</table>
Table 2. Andrea's oral defenses selected for analysis.

<table>
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<tr>
<th>Semesters of Experience</th>
<th>Academic Term</th>
<th>Number per Semester</th>
<th>Student's Name</th>
<th>Student's Course Grade</th>
<th>Grade Distribution Overall for Selected Audiotapes</th>
<th>Number of Oral Defenses per Semester</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Spring '02</td>
<td>4</td>
<td>Kelli C.</td>
<td>B+</td>
<td>A-, B+, B+, B</td>
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<td>1</td>
<td>Spring '02</td>
<td>10</td>
<td>Laura A.</td>
<td>B+</td>
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<tr>
<td>1</td>
<td>Spring '02</td>
<td>11</td>
<td>Meg M.</td>
<td>A-</td>
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<tr>
<td>1</td>
<td>Spring '02</td>
<td>18</td>
<td>Alicia M.</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Fall '02</td>
<td>4</td>
<td>Eric G.</td>
<td>B-</td>
<td>A-, B+, B+, B-</td>
<td>22</td>
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<tr>
<td>2</td>
<td>Fall '02</td>
<td>5</td>
<td>Felicia S.</td>
<td>A-</td>
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<tr>
<td>2</td>
<td>Fall '02</td>
<td>12</td>
<td>Carrie E.</td>
<td>B+</td>
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<tr>
<td>2</td>
<td>Fall '02</td>
<td>17</td>
<td>Ellie A.</td>
<td>B+</td>
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<td>Jen J.</td>
<td>B+</td>
<td>A-, B+, B, C</td>
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<td>3</td>
<td>Spring '03</td>
<td>10</td>
<td>Sally V.</td>
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<td>Sue J.</td>
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<td>3</td>
<td>Spring '03</td>
<td>16</td>
<td>Lola L.</td>
<td>C</td>
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<tr>
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<td>Fall '03</td>
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<td>B</td>
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<td>A-</td>
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<td>C+</td>
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<td>5</td>
<td>Spring '04</td>
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<td>Jess H.</td>
<td>B</td>
<td>A-, A-, B, B-</td>
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<td>5</td>
<td>Spring '04</td>
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<td>Haley J.</td>
<td>B-</td>
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<td>5</td>
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<td>18</td>
<td>Cristal A.</td>
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Table 3. Crystal’s oral defenses selected for analysis.

<table>
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<th>Semesters of Experience</th>
<th>Academic Term</th>
<th>Interview Number per Semester</th>
<th>Student Name</th>
<th>Student's Course Grade</th>
<th>Grade Distribution Overall for Selected Audiotapes</th>
<th>Number of Oral Defenses per Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fall '02</td>
<td>4</td>
<td>Carrie N.</td>
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<td>B+, B+, B, B</td>
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<td>Barb G.</td>
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<td>1</td>
<td>Fall '02</td>
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<td>Erica L.</td>
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<tr>
<td>1</td>
<td>Fall '02</td>
<td>16</td>
<td>Heather H.</td>
<td>B+</td>
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</tr>
<tr>
<td>2</td>
<td>Spring '03</td>
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<td>Angela A.</td>
<td>B</td>
<td>A-, B+, B, B-</td>
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<td>2</td>
<td>Spring '03</td>
<td>5</td>
<td>Janey J.</td>
<td>A-</td>
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<tr>
<td>2</td>
<td>Spring '03</td>
<td>11</td>
<td>Jon J.</td>
<td>B+</td>
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<tr>
<td>2</td>
<td>Spring '03</td>
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<td>B-</td>
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When selecting quotations from various oral defense transcripts, each participant is referred to by number; Joanne is designated as participant 1 (P1), Andrea is participant 2 (P2), and Crystal is participant 3 (P3). The number of semesters of experience the participant had when conducting an oral defense is noted using a number and an S. For instance, the designation S3 refers to the participant’s third semester of experience. When possible, the order in which the oral defense interview was recorded within a semester is designated using an “1” for
interview and a number. For instance, "I5" refers to the fifth interview recorded by a participant during a particular semester. When the order in which oral defenses were recorded was unknown, a designation of "I0" was used. Finally, paragraph numbers within each oral defense transcript were used to designate exactly where a quotation begins. Typically all of the preceding information is combined in a single reference within this document. For example, the reference, P1 S7 I16, Paragraph 29, would refer to an interview conducted by Joanne (P1) during her seventh semester of experience (S7) in which this was the sixteenth interview (I16) she recorded this particular semester; the quotation under study would begin paragraph 29 of the particular transcript. This reference would refer to an oral defense involving Joanne and a student named "Tia J." as listed in Table 1.

To better interpret the flow of dialogue in any oral defense and some of the terminology used in the analysis of the data, one must be familiar with the course objectives for the science methods courses selected for this study:

1. Develop a set of informed personal goals for elementary science instruction aligned with educational research.
2. Exhibit confidence in doing and understanding science.
3. Demonstrate strategies and make connections between the sciences and other areas of the curriculum for themselves and their students.
4. Plan appropriate science instruction that reflects the contributions of Vygotsky, Piaget, and other cognitive and developmental psychologists.
5. Explore children’s understanding and developmental levels.
6. Accurately judge the appropriateness of particular science content issues for elementary students and assist in modifying such content effectively for those students.
7. Plan lessons that accurately reflect the nature of science.
8. Articulate the importance of teaching science and demonstrate the skills for doing so productively.
9. Design and present appropriate hands on science lessons in the classroom.
10. Engage in critical analysis of personal teaching patterns and practices.
11. Produce and orally defend a thorough research-based framework for teaching that reflects and facilitates desired student goals.
12. Review and analyze documents such as *Benchmarks for Science Literacy* and *National Science Education Standards* with respect to elementary science teaching.
13. Experience, critique, and modify existing elementary science curricular materials.
14. Examine and design appropriate methods of assessing student learning.
15. Demonstrate professional and positive behaviors that promote learning, teaching, and science teacher education.

In an oral defense, the participants asked select questions—called initiatory questions—for the purpose of probing each student’s understanding of a number of course objectives. Certain initiatory questions address specific objective(s). For example, the eleventh objective above focuses on a preservice teacher’s ability to develop and articulate how he or she would promote a set of research-supported goals for students. To address each preservice teacher’s depth of understanding on this objective, the following initiatory question is asked during the course of an oral defense: How would you promote the goal of critical thinking in your classroom? This initiatory question varies only slightly among oral defenses as various student goals, such as problem solving or communicating effectively, can be selected for the
aforementioned purpose of examining one’s ability to describe how a specific student goal would be promoted in one’s classroom. Similarly, the tenth objective listed above that focuses on critical analysis of one’s own teaching practice warrants asking each preservice teacher to describe in the oral defense how he or she is going to know if they are an effective teacher. The following list includes the initiatory questions that were asked in some form by the three participants in each oral defense conducted over the course of successive semesters when the participants taught elementary science methods:

- How would you promote the goal of (e.g., critical thinking, problem solving, science content understanding, creativity, communicating effectively) in your classroom?
- What is the value of having multiple strategies and behaviors to promote a goal?
- How would you decide what content you will teach? Similarly, how will you select materials? How will you select activities to teach?
- Two parents come to visit you after school and have a question regarding how you respond to their daughter when she asks you a question. The student is complaining that quite often you don’t answer her question. Instead, you ask her a question in return. How would you justify this sort of response to a student’s question?
- A parent complains about your choice to use cooperative groups in your classroom. How would you justify your decision to use cooperative groups?
- How will you know if you are an effective teacher?

(Modified from Clough & Berg, 1995)

Regardless of the participant, discussion in an oral defense followed the same basic course: The participant, called the “interviewer” in the context of an oral defense, asks an initiatory question. The preservice teacher, called the “student” in
the context of an oral defense, responds to the question. At this point, the interviewer then must make a decision about what to do next to best proceed with the oral defense. In this moment, the participant considers many issues in a short span of time: What was the student trying to convey as he or she responded to the initiatory question? How sophisticated was the student's response? To what extent has the student drawn from and conveyed research-supported ideas in their rationale? What misconceptions might the student have? How confident can an interviewer be in how she has diagnosed the student's thinking? What move(s) could be made next to create a learning experience for the student? This study focused on how each participant managed these questions and then correspondingly made decisions. Important to note is that the number of decision points where the previously mentioned questions are pertinent varies greatly from one oral defense to another and from one participant to another. Additionally, the decision-making that occurs is often cyclical as the participants ask a question, listen and then respond to the student repeatedly throughout an oral defense.

Data Analysis

The process of data analysis involved developing a coding scheme, coding the transcripts for each participant, and displaying the results of the coding process in two visual representations—tables and related graphs as well as profiles.
Coding Procedures

Initially, oral defense transcripts were reviewed repeatedly beginning with Joanne. The order of review was determined by the participant’s experience conducting oral defenses. While reviewing the oral defense transcripts, various responding behaviors that the participants displayed more frequently were identified. Responding behaviors refers collectively to the moves made by the participants after having asked an initiatory question and listened to the student’s response. Each different responding behavior that was identified was designated with a particular code. Each identified code was described in detail and associated with at least one quotation from an interview. The coding scheme is organized into two major categories:

Category 1: Choosing to explain important ideas to the student (E = explaining)

Category 2: Asking probing questions (P = probe).

To better elucidate differences in the interviewers’ decision-making, all interviews were coded using the coding scheme. Two additional practices were employed to ensure consistency in the coding process. First, lists of quotations for select codes were generated and evaluated for consistency. The codes that were selected were the ones that either were most frequently observed and/or were problematic to code in
the coding process. Sixty-one percent of the codes were re-evaluated for consistency.

Second, Joanne and Andrea coded excerpts of transcripts from each participant using the coding scheme. The inter-rater reliability for the coding scheme was 0.83.

The coding scheme (Categories 1 and 2) that was developed follows.

**Coding Scheme: Use of Explanation**

Distinctions regarding how and when the participants chose to explain (E) ideas to the students were developed into a coding scheme consisting of four types:

- **Type 1: Explanation offered with little probing**
- **Type 2: Explanation after attempting to teach through scaffolding**
- **Type 3: Explanation after asking a series of probing questions and the student is unable to answer**
- **Type 4: Explanation coupled with the interviewer asking a series of linked, probing questions**

The section of the coding scheme related to these four types of explanation is described below. Each code is identified by type, code name, definition, and an exemplar.

**Type 1: Explanation offered with little probing**

ATLAS.ti Code: E1A T Explanation w/o much probing

(Note: Each code was assigned a prefix (e.g., E1A) by the researcher as an organization tool for use within the ATLAS.ti software program. The prefix in this particular code is "E1A." Using this notation, a code for an explanation offered by the interviewer is designated with an "E" as compared to using a "P" for designating when an interviewer asks a "probing question." After selecting an "E" or "P," a number follows that refers to a general level of sophistication. A "1" is designated as lower than a "2" than a "3," etc. Codes within each general level of sophistication could differ slightly in sophistication as well. Slight differences in sophistication within a general...
level were then designated with a letter with an “A” being lower than a “B” which is lower than a “C,” etc. When two codes were different in type, but equal in sophistication, they would be designated with the same prefix, but have different descriptions.)

Description: In this code, the teacher or interviewer (I) appears to be attempting to address a problem in the student’s thinking. While the teacher’s decision to explain ideas implies recognition by the teacher that the student’s answer is insufficient, the student may not necessarily recognize that his or her previous responses were lacking. Hence, the student may not be dissatisfied with one’s previous ideas. Instead of working the student (S) toward a richer understanding through a line of questioning, the teacher decides to tell the student what was left out of his or her explanation. "Without much probing" is defined as fewer than two probing questions. A teacher may make this decision because she is at a loss as to what else to do at this point. Alternatively, the teacher could be nearing the end of the oral defense and simply running out of time.

Exemplar: Explanation w/o much probing

Rationale for Code Selection

I: Let’s say we’ve got a, ah, parent who...starts saying, “You know, you’re always putting these kids into cooperative learning groups, and I can’t stand it. Back in my day, we did everything on our own, and we didn’t have to rely on other-other people. And, you know, my kid shouldn’t have to be in these cooperative groups. The way we did it was better.” Um, how would you respond to this parent?

S: Um, first of all, I would say that I respect their opinion and that I understand where they’re coming from, but one of my goals in my classroom is to get kids to be socially interactive with one another and to, um, become friends and to become peers and to become, um-and to be able to, you know, ask other kids in the class what they think about something. Or if there’s a question, they should be able to ask the other kids in the class, um, and not just me all the time. I think that-I think the-err, cooperative groups are applying, too, because, um, it shows through-it gets students other perspectives, um-not just what I’m saying, but what the other kids are saying. Sometimes the
Notice how the student has not drawn from learning theory.

Notice how the interviewer chooses to explain content related to learning theory rather than continue asking probing questions.

Teacher can drill and drill and drill. Um, sometimes with the students, another student can just say, you know, one sentence, and they’re like, “Oh, I get it.” They—they learn off each other; they feed off of each other. So that’s what I think I would say—that I want the kids to be socially interactive...which is going to help them communicate in the real world. And they need to be able to, um, have them as a resource in the classroom setting.

I: And I think social learning theory, too, comes into a play a lot, because kids actually do learn the content better when they have the chance to work with each other. So it’s not just the social goals that you have for your students, but also a content goal, um, at the same time. (Reference: P1 S2 I0, Paragraph 51)

Type 2: Explanation after attempting to teach through scaffolding

ATLAS.ti Code: E2A Explanation with attempted scaffolding

Description: In this case, the interviewer (I) appears to recognize that the ideas conveyed by the student (S) are less credible as noted by the interviewer’s attempt to design a line of questioning that addresses concern(s). However, relatively soon after attempting to construct a line of probing questions, the interviewer shifts from questioning to explaining important ideas that have yet to be discussed.

Exemplar: Explanation with attempted scaffolding

Rationale for Code Selection

I: So if you want to find an activity to teach erosion, what would you do? I mean here you are in a classroom and there is no nice kit sitting in your classroom. What would you do?

S: You could do research on the internet and look through lesson books. Talk to another teacher. There’s no way of knowing whether the lesson pulled off the web is going to work though and this is limiting given my lack of experience.

I: What are some things that you could look for to tell you whether or not a lesson is going to work?

S: For my class, cooperative learning. Hands on. Check
Notice that the interviewer prompts the student to consider learning theory. The student responds by stating only declarative knowledge related to learning theory. Further, the student seems to indirectly equate learning theory with strategies, such as "hands on instruction."

Notice that the interviewer asked two very similar probing questions related to learning theory and continued the discussion through explanation rather than asking more probing questions.

Notice that the interviewer has shifted to a new initiatory question.

grade level and how it coincides with district requirements and with what kids can do.
I: How would learning theory fit into that?
S: [Pause] That the kids are using hands on materials. The teacher would be facilitating the activity.
I: What else?
S: That the teacher’s behaviors would work to get to the lesson.
I: How about constructivist learning theory? Does this fit into this at all?
S: Did you read the very end of my paper? I hate the names of the different theories. I just think it’s a waste of time to learn those. Constructivist is the one wanting prior knowledge, hands on, and student-centered, correct? So that would work with my student actions and teacher behaviors.
I: I’d encourage you to just think of more than terms for learning theory, because...each one of them attempts to describe how people learn and each one of them is looking at it through a bit of a different lens. There are sort of four lenses that we’re using right now to describe what we’re seeing kids doing. If you’re out there trying to pick and choose materials and you have a lesson plan in front of you from the internet, certainly it’s appropriate to look at the grade level that’s indicated. Are they working in groups or not because that’s obviously going after one of your goals? Is it matching the curriculum well enough that’s mandated for you? Is it hands on? What’s your role in this? And obviously connecting back to your student actions and things. I would also add that learning theory ties in here because we need to ask if this activity is developmentally appropriate. As we saw with Piaget’s work, kids are reasoning very differently than we are depending on their age level. And even though it may say, “Grade 4,” it may not be developmentally appropriate so that’s definitely something you need to consider. So last but not least, why do you think it’s important that a person who’s about to enter the teaching profession to be
able to articulate something like this paper? (Reference: P1 S1 I0, Paragraph 80)

Type 3: Explanation after asking a series of probing questions and the student is unable to answer

ATLAS.ti Code: E2A T Explanation after S is unable to answer

Description: In this case, the student (S) has "bottomed out" and is still missing some critical information, such as a discussion of the teacher's role, in his or her rationale. The interviewer (I) has probed the student's thinking extensively and the student cannot produce any more pertinent information, often admitting to the interviewer that he or she can not think of anything else to add to the discussion. At this point, the interviewer chooses to explain information that was missing from the student's responses. This move is somewhat sophisticated because the student is likely to be at least partially dissatisfied with their previous ideas given that one was asked a series of questions to the point where no further pertinent information could be added. In this sense, the interviewer helped to create a situation where the student now has a heightened "need to know." However, what the student learns from the interviewer's explanation is generally not evident in the transcript. Typically, when the interviewer is finished with her explanation, she moves to a new line of questioning and/or topic. Hence, it is difficult to draw conclusions about what new learning the student has put together.

Exemplar: T Explanation after S is unable to answer

Rationale for Code Selection

I: So let's suppose you are in your first year of teaching and a parent comes in--angry, and says, "You know, I just can't stand the way you're teaching my kid. She comes home and tells me that you're putting her in all these crazy cooperative groups all the time and boy, back in my day, we used to do everything on our own. We had our stuff in front of us, we'd turn it into the teacher, and the teacher was doing their job of teaching." How would you respond to this parent?
S: Um, talking to parents is kind of a different issue, um. I don't do well with confrontation so this is kind of a thing for me to--you can't really plan for. I really--I can't see myself practicing what I'm going to say and I think it's a
Notice that the student mentions learning theory briefly in her rationale, but her understanding seems impartial or perhaps she has a misconception.

good idea to have it said because once you’re out one and one you just don’t want the wrong thing to come out of your mouth, especially to an angry teacher or angry parent. I think I would just kinda explain to them that things have changed and from what we know about how kids learn now, they do learn better with other students. You know I could maybe--depends on who the parent is--I could say social learning theory says kids work better when they model after other kids. Then I could see them saying, well, what if they’re working with a whole bunch of dummies. I could hear the parent saying something like that and then you know I could come back and say, well, that may be true, but they’re going to be teaching other kids and from that teaching they’re going to be learning so much more. I think you just kinda need to state to them that you know four minds are better than one. They’re going to learn from each other and, in turn, the kids are going to learn from your son or daughter. And I guess you really need to explain to them, to that parent, they’re going to learn better in a group. You know we don’t do everything in groups. You know we don’t take our assessments in groups, but we do individual assessments.

I: So let’s suppose that that parent is still not convinced and says “Well, isn’t it your job to do the teaching and not the other kids in the group?”

S: I can explain that, um, I have a student centered classroom and my job is to put the learning on the kids. Um, a teacher--from what I learned from my education is that, um, having a student centered environment is a much more positive environment than the traditional teaching where kids are sitting in their neat rows and I’m up there writing on the chalkboard. Kids are going to learn more now. But like I see that, in a sense, hurts me because I can see them saying, “Well, I learned just fine,” so I don’t know. I think that’s where I bottomed out on dealing with parents. Yah, I think I have bottomed out there.

I: Another way you might want to approach this is to look
Notice that the student appears receptive to the ideas conveyed by the interviewer.

at your goals and say, "Not only am I teaching content." In a traditional classroom..., the teacher just wanted you to learn the content. But I'm preparing my kids for when they get out in the world and function as citizens and that means that I want them to be cooperative. I want them to be critical thinkers. I want them to problem solve. I want them to learn content and I want them to apply it. And all of these things are done much better when they can actually do those things in groups with other students than they can if they are just by themselves."

S: Can I write that down? That's really good.

I: Yes, and so tie it to both ends because you know what you are doing is supported by how kids learn and also directed at your goals. And I would encourage you that when, you know, you have that first meeting with the parents at the beginning of the school year, I'd hand out my goals and say this is what I expect from my students this year. This is where I'm trying to take them.

S: That's a good idea. I like that and that way they'll know where you're going.

I: And then you can reassure them that the strategies that you choose—you're going to use lots of them, but they are directed toward these goals.

S: Okay, so that sounds so much better.

I: So how would you use a pretest...in your teaching?"

(Reference: P1 S3 I 17, Paragraph 51)

Type 4: Explanation coupled with the interviewer asking a series of linked, probing questions

ATLAS.TI Code: E3A T Explanation coupled with scaffolding

Description: In this case, the interviewer (I) makes a series of decisions prior to explaining information to the student (S). The interviewer has presented an initiatory question to the student and probed the student's thinking where deemed necessary to ensure a more accurate diagnosis of the student's ideas. In response to this evaluation, the interviewer creates a line of questioning that is tightly connected and consists of multiple, short answer questions. Through these short answer questions, the interviewer creates a situation where the student conveys a new
understanding in his or her own words. Then the interviewer elaborates on ideas conveyed originally by the student.

Exemplar: Explanation coupled with scaffolding

Rationale for Code Selection

Notice that the student mentions how she plans to praise students publicly as well as individually.

Notice that the interviewer questions the student to consider possible negative effects of praising students publicly.

I: Now, praise is a positive thing to use in a classroom. So, when or how would you want to praise students?
S: I think one is situational. Whether it is done individually or if it is at the beginning of a lesson or at the beginning of the day, it could be in groups where a student is doing something well. I think it is a good thing to respond to them even if it is like classroom management stuff. "Oh, well, this person is doing a great job sitting at their desk and already has their desk cleared." I think that is a good way to praise them because it makes the other students want to do what they’re doing, too, and then...
I: For what reason does it make the other students want to do what that student was doing?
S: Because they’re looking for my attention or they’re looking for praise from me, too. I don’t know.
I: How might praising students in front of other students keep a student from wanting to do that again?
S: It would cause embarrassing situations sometimes. Maybe a teacher would then be looking for them to do it again and they may not respond well to that added pressure.
I: So what might be a better way to praise a student?
S: Other than saying their name?
I: Other than saying, “Hey, you’re doing a great job,” in front of everybody.
S: Even just putting a sticker on their desk or you could walk by and say, nice job, thanks for doing that. More like a quiet “good job”, “thank you” type of thing. I don’t know. That’s what I would do.
I: How might pulling a student aside or just one group and praising a group in private be a good thing?
S: I’m going to put this in context of what happened
Notice that the student now mentions the importance of praising in private.

Now the interviewer elaborates on ideas regarding effective praise; some of which were mentioned previously by the student.

yesterday. I stopped and helped an old lady into her car yesterday. It was icy and I was walking by and I didn’t know her, but I wanted to help. I’m glad I did it, but I don’t care that other people know that I did that. So, in pulling kids aside, it would be kind of like, you guys are doing an awesome job or thank you for doing this or I’m so glad that you figured that out. It just makes me feel that it is more individual. It is their own personal praise. It is just like writing a note to a student, and saying thank you. It’s more personal instead of if I were to say, I’m telling you this because I want the rest of the class to do that, too.

I: So if you want praise to be more personal and special, how might you word your praise so that a student would know that you value what they’ve done and that you find what they’ve done a very unique and special thing?

S: I would definitely use specifics. I would not say, "good job."

I: So, how would you phrase it?

S: I would say... if a student had all their homework done and they were just using the time wisely... wow, you are really thinking. And I saw that you were on task and you were staying organized which is really great. Rather than saying "great job with your time management" or something like that, it lets them know that I’m paying attention to them and that I don’t have to praise them for everything good that they’re doing. I just can’t. But I was still watching and I am thankful for their effort.

I: And I think that all the research on effective praise says that first praise needs to be very private. There are also reasons why praise would be a hindrance in a classroom if you do it in front of a lot of students. And that it really is much more effective if you pull a student aside and say something to them or write them a note. And secondly, that, yah, if we would do it privately, but also be very, very specific and I know that I didn’t give praise in methods very often, but there were a couple of occasions when I would go up to people before class or after class and say, "Hey, you brought something up in class last
time and I know that you were kind of on your own. Maybe no one agreed with you, but I appreciate that you brought that up. We needed to have that.... I maybe didn’t say, “Great job!” But, just based on what I said, I think the student knew that I really valued what they had done. I also think that if you don’t do it very often, then when you do, it does mean a lot more. And I’m always concerned about research that says that the lower level students get praised for doing very low level expectation type tasks....I’m not at all saying that we never praise, but I think how we do it is extremely important and we want to keep our goals in mind and we know that all the literature on praise and then all the teacher behaviors indicate that praise is effective when done right. And so for all those reasons, we wouldn’t want to do it in the middle of a class discussion or something like that. (Reference: P2 S4 I11, Paragraph 109)

**Coding Scheme: Use of Probing Questions**

A coding scheme regarding the participants’ decision-making when using probing questions (P) was developed and divided into seventeen types:

- **Type 1:** Interviewer chooses not to ask any probing questions
- **Type 2:** Interviewer shows difficulty when attempting to construct a probing question
- **Type 3:** Interviewer asks similar, successive questions
- **Type 4:** Interviewer offers feedback by listing ideas the student has mentioned and then asks for more information
- **Type 5:** Interviewer probes a student’s vague use of terminology by asking the student to explain a term further
- **Type 6:** Interviewer probes whether the student can articulate how to apply knowledge
- **Type 7:** Interviewer attempts to confront student’s ideas, but the student evades the confrontation
- **Type 8:** Use of a critical incident involving an extremely challenging scenario
Type 9: Use of a critical incident is underdeveloped (truncated line of questioning)
Type 10: Interviewer attempts to use scaffolding to create a learning experience, but the result is less effective
Type 11: Interviewer shifts focus of questioning to an important “link”
Type 12: Interviewer probes whether the student can further articulate a rationale for a decision
Type 13: Interviewer asks a student to confront a naïve aspect of one’s reasoning
Type 14: Use of a critical incident to better diagnose student thinking
Type 15: Use of a concrete experience within a series of linked questions that are designed to create a learning experience for the student
Type 16: Use of a critical incident to better diagnose and create a learning experience for the student
Type 17: Interviewer asks a series of questions that are subtly related and culminate in asking the student to revisit contradictory ideas

The section of the coding scheme related to asking probing questions follows. Each code is identified by type, code name, definition, and associated with an exemplar.

Type 1: Interviewer chooses not to ask any probing questions
ATLAS.ti Code: P1A T No probing Qs
Description: This decision is evidence of difficulty framing follow-up questions. In this case, the interviewer (I) has asked an initiatory question and listened to the student’s initial response. The student’s answer is incomplete and/or contains inaccurate ideas(s). However, the interviewer does not choose to ask any probing questions. Instead, the dialogue shifts to a new initiatory question.

Exemplar: No probing Qs

Rationale for Code Selection

Initiatory question

I: So what’s the value of having multiple strategies to get at a particular goal?
Student (S): If one strategy isn’t working, then you have other strategies you can try.
I: Let’s say you’re in your first year teaching and you have a parent who comes to you and is just angry. And says, “My
kid yesterday in science asked you a question and all he wanted to know was, why are earthworms on the sidewalk when it rains? And you came back to him with another question like, “I don’t know. How could we find that out?” How would you respond to this parent? (Reference: P1 S1 I0, Paragraph 38)

Type 2: Interviewer shows difficulty when attempting to construct a probing question

ATLAS.ti Code: P1B T Minor struggles (stutters, embedded Qs, listening difficulties)

Description: This decision is evidence of difficulty framing follow-up questions. The difficulty that the interviewer (I) encounters is manifest in various forms. The interviewer may appear to stutter as she works to shape a question. The interviewer may embed questions within questions in a confusing manner that makes it difficult for the student (S) to understand what to address. The interviewer may ask a question that the student has already answered (evidence of difficulty listening) making the conversation circular and less productive.

Exemplar: T Minor struggles (stutters, embedded Qs, listening difficulties)

Rationale for Code Selection

Notice that the interviewer asks two questions here without pausing. The student is likely confused as to which question to answer.

Rationale for Code Selection

The last question in this sequence has already been addressed by the student. The student mentioned previously that she had taped herself and analyzed her questioning using a systematic tool (SATIC coding guide). Further, she mentioned that she was concerned about how many yes/no questions she asked.

I: You can get kids to talk to kids without even having to do directions. So let’s break this down. You pose the initial question and the first kid starts responding. Who’s that kid primarily going to be look at? How do you get that kid to look to the other students rather than you without having to tell him? (Reference: P1 S6 I5, Paragraph 078)

I: How did you measure your effectiveness in the taping analysis?

S: How? I struggled! [laughter] I struggled a lot with the analysis of my questioning. I was finding that I did a lot more yes and no questions, not the in-depth ones.

I: How did you go about recognizing that?

S: Just listening to it. By doing that I recognize that I am twice as likely to be near the beginning then towards the end of the SATIC coding guide [a systematic tool for analyzing one’s questioning strategies]. I have known that
Yet, the interviewer asked the student whether she had considered the kind of question that she tended to ask.

questioning is one area that--I just can’t formulate a question that pulls knowledge from them.

I: Have you ever thought about the kind of question that you’re asking? (Reference: P3 S3 I17, Paragraph 121)

Type 3: Interviewer asks similar, successive questions

ATLAS.ti Code: P1C T Repetitive Qs (similar in cognitive demand)

Description: In this case, the interviewer (I) asks at least two probing questions that are repetitive and very similar in cognitive demand. At times, this sort of questioning may be helpful diagnostically because such questioning encourages the student (S) to continue talking about an idea and present as much information as possible on a question. However, when the interviewer is confident in the student’s level of understanding and is attempting to create a learning experience for the student, this line of questioning does not appear to greatly assist the student in linking challenging ideas together.

Exemplar: Repetitive Qs (similar in cognitive demand)

Rationale for Code Selection

Notably, the two questions asked by the interviewer are essentially identical.

I: So why do you think it is important to be able to articulate what you have written here rather than just writing your paper and turning it in?
S: The whole value of this discussion is how I’m going to teach. I feel I can articulate everything that is in my paper. Although I may change my goals depending on her class.
I: So why is it so important that you’re able to talk through this [paper] rather than just have it written? (Reference: P1 S1 I10, Paragraph 67)

Type 4: Interviewer offers feedback by listing ideas the student has mentioned and then asks for more information

ATLAS.ti Code: P1D T takes inventory of responses (what else?)

Description: This code is useful for diagnostic purposes and for providing feedback to the student (S) as to what was conveyed in previous response(s). In this case, the interviewer (I) has asked an initiatory question and the student has responded. Subsequently, the interviewer lists for the student any pertinent information that was conveyed previously and then asks the question, what else would you consider? Implied in this message is the notion that what the student has
conveyed thus far is incomplete given that the interviewer has asked for more information. In general, this code has the following pattern:

I: You’ve mentioned a number of strategies, such as __, __, and __. What other strategies would you use?

Exemplar: T takes inventory of responses (what else?)

Rationale for Code Selection

Interviewer tells the student that she has mentioned three kinds of activities (class discussions, open ended questioning and use of assessments). Then she asks, “what are some other...?”

I: So far you have talked about activities that require kids to critically think; class discussions which would also get kids thinking about different things with each other; open ended questioning and how you would use your assessments to get at critical thinking. What are some other things that you could do to get kids critically thinking? (Reference: P1 S3 I6, Paragraph 19)

Type 5: Interviewer probes a student’s vague use of terminology by asking the student to explain a term further

ATLAS.ti Code: P2A S Vague on terminology/T probes declarative knowledge

Description: The scenario for this code is as follows. The student (S) has just used educational language in his or her response, but the lack of information in the response or the declarative nature of the comments makes it difficult for the interviewer (I) to be confident that the student has a rich understanding of the terminology. The interviewer (I) responds to the student’s vague comment by asking for more information (e.g., what do you mean by?). This sort of question could be answered easily by the student simply by repeating a memorized definition or a list of information. This sort of question can be useful for better diagnosing the student’s thinking on a topic. However, this kind of question focuses more on a student’s understanding of a definition. The pattern for this code is as follows:

I: You mentioned that you would scaffold student’s ideas. What do you mean by scaffold?

Exemplar: S Vague on terminology/T probes declarative knowledge

Rationale for Code Selection

Mentioning the importance of using “good questions” is less sophisticated than describing and

I: In order for your wait time to be effective, what else would you need to be doing?

S: Questioning your students and asking them good
exemplifying a good question; thus, the interviewer asks the student to explain what she means.

I: What's a good question? (Reference: P2 S5 I4, Paragraph 23)

Type 6: Interviewer probes whether the student can articulate how to apply knowledge

ATLAS.ti Code: P2B S Vague on application/T probes

Description: In this case, the interviewer (I) is responding to a student's vague response by asking the student (S) to apply information. This code is similar to the probe identified as "S vague on terminology/T probes" in that, in both cases, the student has conveyed information vaguely. However, the response by the interviewer in this case is to ask the student to apply his or her understanding of terminology by describing ACTION(S) associated with the terms in question. The pattern for this code is as follows:

I: What would I notice if I saw you _____?
OR
I: You mentioned that you would act as a facilitator during an activity. If I peeked into your classroom while you were facilitating, what would I observe you doing?

Exemplar: S Vague on application/T probes

Rationale for Code Selection

Student claims she will "facilitate." What does this mean?
The interviewer asks the student to articulate what action she believes is associated with "facilitating."

I: How would you get kids to problem solve in your classroom?
S: I would consider the activity chosen. I may need to modify the activity that I find when I'm looking. I'd also use cooperative groups where I would act as a facilitator and make sure students stay on task.
I: How would you do that? (Reference: P1 S1 I0, Paragraph 8)

Type 7: Interviewer attempts to confront student's ideas, but the student evades the confrontation

ATLAS.ti Code: P2C T asks Confronting Q (S evades)

Description: From the perspective of the interviewer, the student (S) is somewhat "caught" in this case. The student is "caught" in that he or she may have conveyed contradictory remarks or remarks that lack credibility. Interestingly, the
student may or may not be aware of any insufficiencies in the responses. In an attempt to make this evident to the student, the interviewer (I) asks a question that challenges the student to confront inadequacies in the previous responses. Interestingly, for this code to apply, the interviewer’s attempt FAILS to create a situation where the student realizes any insufficiencies. In other words, the student makes no explicit comment(s) to confirm that he or she also recognizes insufficiencies in one’s remarks and, thus, the student effectively evades the confrontation. This sort of response by the student is not surprising in view of research related to conceptual change. Students will often interpret incoming information and vehemently defend their prior ideas before radically changing their views.

Exemplar: T asks Confronting Q (S evades)

Rationale for Code Selection

I: Let’s say you have a group of kids and they are on task. They’re in a cooperative group. They’ve got a good activity that you’ve modified to get them problem solving. So they have a problem in front of them, they have a group; they’re on task and they have no idea how to solve the problem. What do you do?
S: I would give them some subtle hints to get them going. And try to make these clues into questions—What if you do this? What if you change this?
I: Would that lead them more toward the solution or more toward being better able to solve problems in the future?
S: Both.
I: So you said questions. You’d ask questions. What kinds of questions would you ask? (Reference: P1 S1 I0, Paragraph 14)

Notably, the student evades confronting any problems in his previous responses.

The interviewer shifts to a different line of questioning.

Type 8: Use of a critical incident involving an extremely challenging scenario

ATLAS.ti Code: P2C T Critical incident (extreme case)

Description: In this case, the interviewer has diagnosed a student’s thinking and now is trying to teach the student. The line of questioning initiated by the interviewer begins by the interviewer (I) creating a critical incident that the student (S) will likely encounter in practice; however, the situation that is selected typically involves an extreme situation. In this instance, the extreme scenario tends to be very
difficult for the student to address and often little evidence of student learning is noted.

Exemplar: T Critical incident (extreme case)

Rationale for Code Selection

This critical incident is considered extreme because the notion that "the kids have no idea what to do" characterizes the challenge that is presented.

I: Let's take an example here. Let's suppose you have cooperative groups of kids set up in your room where students have enough space to work. You're walking around doing some monitoring. You've chosen really good problems. The kids are ready to go. They're excited. They're motivated. They have really good social skills. They're working together. They look at this problem and they say, "I have no idea what to do. I give up."

S: I would say, "Let's look at this again." I would ask, "How can we even think about solving this? Is there any way we could break this down into a smaller problem? Have you seen anything like this that may be similar to this? Have you experienced anything that may be similar to this? This would hopefully give them a push to get them going.

I: Those were all yes/no questions though that you just asked, so how would you...

S: OK. I guess I would say, "How can you solve this?"

I: And they say, "I don't know." How then could you teach them to problem solve?

S: Do the kids have models in front of them or anything like that?

I: Right now, they have this problem in front of them and no skills to solve them.

S: I would ask, "What does it need to survive? And then asks a series of follow-up questions that help students relate the topic to things from their own lives.

I: Is problem solving an innate ability or is it a skill that is developed?

S: I think you have some ability, but I think it is really a skill that is developed with experience.

I: All right so...you're going to ask good questions and try to get it to relate to some similarities that they see in their
own lives. What else could you do to teach them how to solve this particular problem?
S: You could give an example to them. Perhaps have students look at what other groups are doing and use little pieces of what others are doing. Sometimes students are punished for that, but they’re really being resourceful.
I: Well…and I think there is research to support that modeling idea. They are going to learn from models and that’s other students so [pause]. Okay. Let’s suppose you’re in your first year teaching and a parent comes to you angry. And says, “My kid came to you and asked this morning why when it rains there are earth worms all over the sidewalk and you responded by asking her a question rather than just giving her the answer. You turned around and said something like, “I don’t know. How can we find out?” How would you explain yourself to that parent? (Reference: P1 S1 I0, Paragraph 19)

Type 9: Use of a critical incident is underdeveloped (truncated line of questioning)
ATLAS.ti Code: P2C Critical incident (truncated questioning)

Description: A critical incident is used to initiate a line of questioning with the intent to further diagnose as well as teach the student (S); however, learning through further questioning or explanation is very limited. This code is characterized by the interviewer (I) truncating the original line of questioning and suddenly shifting the questioning to a new topic; thus, leaving certain important topics unaddressed.

Exemplar: T Critical incident (truncated questioning)
Rationale for Code Selection

I: Let’s say that you are full-time teaching and a practicum student is in your classroom.
S: Uh-huh.
I: And the student observes you in those scenarios conducting a large group class discussion. She’s been in your class for a number of weeks so she’s more familiar with you. The students...are also familiar with her. And she notices that it is through these class discussions that quite often she is impressed with the learning that takes place. She tries herself in a subsequent lesson to
incorporate class discussion and it falls down she thinks. So now she's coming to you for consideration. What is intriguing in this situation is that you knew she was going to incorporate class discussion into her lesson plans. You had had that conversation with her prior to the lesson and you made mention then, OK, I think you need to consider carefully the questions you are going to ask. So together you had written out those questions. She used those in her lesson, but still she is coming to you for advice to try to get the kind of interaction pattern that you had where not only was the teacher interacting with various students, but you in fact eventually had student to student to student interaction going on in your class discussion. What advice would you offer her on conducting a class discussion?

S: Wow. The first things that come to mind are the consideration of your body language. You know, are you engaging them in the conversations? I have a really bad habit of cutting them off. I need to be quiet. So are you allowing them that time which basically is wait time on the teachers part so that the student is able to convey to you all of what they want to say? And then not only that, but your affirmation or confirmation of what they have said--are you then stopping that conversation? Are you being a block to the other students? So I would take into consideration her wait time. Did she allow the students to speak? And not only that, but just because one student has spoken doesn't mean that the conversation is done. Did you engage in other ways to build on what that person had said or did other students have a comment about that? Then secondly, I think that your body language can say a lot. So, where was she in the classroom? Did she have a frown after every response? My practicum teacher--I thought this was a really good--she always went like this--she pointed to the side of her head and kind of was like, okay, I'm thinking about what you said. So they continued to do that as well. So I thought that was really good modeling of that. I think
related to effective use of praise; further, she seems to indicate that she will praise more globally and broadly using phrases like, "good job" which contradicts literature related to effective praise. Notice that the interviewer probes to better understand the student's use of acknowledgment.

even if I did help her with the questions and we thought that they were good at that time, perhaps we need to go back and look at the questions again and reconsider what we had come up with. Maybe there was something that we didn't consider. The other thing, too, is why is she feeling that it failed? And did it really? Does she have an accurate assessment of what really took place? So that discussion failed--well, why did it fail? Did it fail because the children didn't learn? Or because the children didn't accomplish the objective she set for them? Or perhaps it didn't last long enough? Or exactly what was the problem?

I: What advice would you offer her when she's thinking carefully about affirming or confirming a student's response?

S: I think you have to take into consideration the particular students who are responding to her. Although, I think that in some parts of your lesson you want more than one answer so you may just want to acknowledge rather than affirm a student's answer so you get more input. And then maybe there are times when you just do want one answer and so then that is going to look different than an acknowledgment--that is going to be a confirmation. That is a "thank you for the answer" or "you're right" or "correct" or "good job."

I: What would effective acknowledgment look like?

S: To me that looks like more body language than even saying anything, just nodding your head and maybe saying thank you.

I: Keep going.

S: Um, you could even--obviously I think you need to record everything so that the students can keep track, so you can record things on the board and then you can turn to the class as if you're obviously wanting more. I think they're going to know that because you have turned to them that you are still waiting--that wait time--so that student probably didn't get any confirmation other than recording the answer on the board.
I: As we look back on the things we have talked about so far. We’ve talked about a lot of things that the teachers would be doing and different things that the students will be doing in that process, peer to peer interaction, authentic activity and considering questions that the teacher is posing. What are some reasons to support those decisions? (Reference: P3 S4 I25, Paragraph 013)

Type 10: Interviewer attempts to use scaffolding to create a learning experience, but the result is less effective

ATLAS.ti Code: P2C T Scaffolding attempt (less effective)

Description: In this case, the interviewer (I) has asked an initiatory question and recognized that the student’s response, thus far, is missing important idea(s). The interviewer then asks linked questions implying that she is trying to create a situation where the student’s understanding deepens. However, the line of questioning and responses between the interviewer and student leaves certain critical issues unresolved through questioning. In this line of questioning, the student (S) may effectively evade critical issues and/or one may not have the prerequisite knowledge to answer the question under study; in this case, the student often says, "I don't know." The characteristic feature of this code is that the interviewer seems to "give up" in a sense.

Exemplar: T Scaffolding attempt (less effective)

Rationale for Code Selection

I: Let's suppose that when asking a question you do not get the effect that you want. Other things might not be there. For instance if I was looking [away] like this and I asked a class a discussion question, the kids probably wouldn't run with it. If I need to get it go kid to kid to kid [to have a class discussion], I have to do other things. Given that, why do I have to have multiple strategies and behaviors in the classroom to pull off content and understanding? I know that's a complex question so if you can't run with it, that's fine.

S: Ah, you need multiple strategies to get different kids involved.

I: Think of it this way. I'll get no kid involved if I ask a good question with bad wait time. The question can't

Notice that the student doesn't recognize the synergistic relationship among teacher behaviors, such as questioning and wait time. The interviewer responds by asking a very
leading question here, but the student is unable to answer any further.

Now the interviewer uses explanation rather than asking additional questions.

stand alone. What has to go with good questioning?
S: Well, the non-verbals, like you said. Um, gestures like you said. Um...
I: So why would I need multiple strategies or multiple behaviors?
S: I don't know.
I: Okay, that's all right. I'm trying to see where I can go with this. If you have multiple strategies you have a much better chance that you're going to get to the goals that you have. And also because if you do something and it's not working, it's not that you throw it out and try something else. It's that it might have to go along with ten other strategies. So my teacher behaviors have to come as a big huge package. If I ask a great question, but don't use good wait time or use inappropriate non-verbals or don't respond well, it's not going to have the impact that I want. So to get at any goal—content, critical thinking, problem solving, whatever—I'm going to have to use multiple strategies in tandem to get all those things to happen. So I can't just use a good activity. I also have to use my behaviors appropriately and all of that at the same time. So there's this complex interaction that happens.
(Reference: PI S7 I5, Paragraph 68)

Type 11: Interviewer shifts focus of questioning to an important "link"
ATLAS.ti Code: P3A S Missing an important "link"/T shifts focus to "link"

Description: In this case, the student's previous response(s) fail to consider a credible idea, such as the importance of self-assessment or grounding instruction on how people learn. When the interviewer (I) responds in this situation, the student (S) is directed with varying degrees of explicitness to consider a certain idea that he or she has NOT MENTIONED thus far. Generally, the response sounds like, "So, how is your decision consistent with _____ (e.g., learning theory)?" The implicit intent of the interviewer when making this particular decision is very similar to the intent conveyed when the interviewer asks the student to expound on their rationale for a particular decision (ATLAS.ti Code: S vague on rationale/T probes). A fine, but important, distinction exists between these two codes: When the student has vaguely mentioned their rationale and the interviewer probes for more information, the code is "S vague on rationale." Alternatively, when the student has not explicitly
mentioned how their decision is consistent with research-based ideas and the interviewer directs the student to consider an important resource, then the code selection is "missing an important link."

Exemplar: S Missing an important" link"/T shifts focus to "link"

Rationale for Code Selection

I: Let's say you have a parent who comes to your door. And this parent says, "When I went to school, we all sat in rows. And the teacher told us and we learned. We did our work individually and we learned. And my son has come home and said that you work in groups a lot in your class. And he's smart--he's really smart -and I'm just afraid because you're not teaching him that he is not going to learn what it needs to know." How would you respond to this parent?

S: I would say, at my age, I came from the same schools you did....But through the advantage of research, we found out that people learn better by getting hands on and...being able to see it and play with it and test their theories...themselves and that's what I am trying to implement here--to get that curiosity in your son so that he will not only look at this class, but at every class, and start questioning. I think it is sad that we lose that. When we're young, we say, why mommy why, why? And then we get to school, and in the first year or two, we lose it....And I personally think, like myself, I take it home and I outline it. I've had to bring it back to myself and continue asking why. Like I said, I love astronomy because it has raised all kinds of questions. And this science methods class has raised all kinds of questions. And the literature I have read has raised all kinds of questions that were not answered in class. But now it is up to me to try to go out and find out those things. So what I'm trying to do with your son is pique his curiosity...so he will want to know why and take that curiosity out of here and not just look at the sun setting, but ask, why is it setting in the West?

I: How will you respond to this parent's concern that they're not going to learn as much in a group setting?
that focuses, in this case, on views of learning in a group setting.

Rationale for Code Selection

I: Okay, you’re in a fifth grade classroom. It’s the beginning of the year, a progressive district. How are you going to decide what content to teach your students?
S: That’s a really good question I think. Um, well, first, I’d check to see if the district has any kind of school standards for what needs to be taught and, um, I’d probably-probably base off that so then, yah, I’d want to-I’d want to do, like I’d actually want to do stuff where the students like-have these big overarching goals or projects where they, you know, just find out about seasons, where they learn about chlorophyll and xylem and phloem, you know? I’d want to do what I-so they hit a few subjects, but they get deep into them instead of all these broad things where they don’t learn anything. I think that would be... Especially what I foresee as the toughest thing that I can teach is if the district-like, they’ll want-they want me-they require that you have to teach them about all these different terms and stuff and I would just-I would hate that. That would drive me nuts.
I: [laughs]
S: But I think-a lot of it, too, I’d want to teach ‘em stuff, but I’d also want to, like, where the kids-like, even having the students come up with ideas of what-what they want to learn. And even, like, do that the first week and kind of tie that together with what-what they need to learn so that they see that they’re learning what they came up for ideas, but also on my part is accomplishing standards that need to get taught also. But I think-like, if it’s a standardized test and that sort of thing that’d be like a paradox.
I: How would your decision-making be influenced by what we know about kids-how kids learn?
S: Based on the developmental levels-where they’re at, whether they, err, need to....Most of them, I guess, at the age where I’ll be teaching, they need to do hands on
activities. They need to be manipulating, according to Piaget. And, [chuckles] like, group work is very important because, um, not only does it teach them to work with others, but it-it helps-it encourages critical and creative thinking, um—all the social skills. And also it kind of helps build classroom community where it’s a safe environment for them. What was your question again?

I: How would your decisions draw from what we know about how kids learn?

S: Okay. Um... (Reference: P3 S2 I11, Paragraph 45)

Type 12: Interviewer probes whether the student can further articulate a rationale for a decision

ATLAS.ti Code: P3A S Vague on rationale/T probes

Description: This probe by the interviewer (I) further examines the credibility and richness of a student’s rationale for a decision. Through the course of previous questioning, the student (S) eludes to and/or explicitly references an idea, such as using wait time or asking open-ended questions or relying on learning theory; however, the explanation is too brief to be confident in his or her understanding overall. This code is very similar to the code labeled “missing an important link” with one fine distinction: If the interviewer asks the student to consider an idea that the student has NOT previously mentioned, then the code to be selected is “missing an important link” (ATLAS.ti Code: S missing an important link”/T shifts focus to “link”). If a student mentioned ideas pertaining to a rationale, but he or she lacks credibility and the interviewer pursues certain issues, then the code is “vague on rationale” (ATLAS.ti Code: Vague on rationale/T probes).

Exemplar: S Vague on rationale/T probes

Rationale for Code Selection

Notice that the student mentions she will analyze videotapes of her teaching to determine her effectiveness.

Notice that the student mentions she plans to

I: Um, so how are you going to assess yourself as a teacher?

S: Um, I'm going to want to videotape myself once in a while. Um, I want to-then, through the videotape, I can look at my questioning and my wait time towards students, um, when I ask questions. Um, having other people come in to observe me, other teachers just to come in to observe me, and then they can give me suggestions. Um... And another thing is writing down the goals that I
might have and then, like, maybe even writing down things—um, each day, like, things that I think I have done to improve and things that I think that I can improve on to, um, reach that goal. That’s about it.

I: Okay, so if you were going to videotape, what would you look for?

S: Questioning. Um, maybe my, um, non-verbs, my proximity, getting different students interacting through the discussion or whatever we’re doing at that time. Um..., my Wait Time. And—I don’t know—making sure that I’m not giving students the answers and I’m questioning them to get them to come up with the answers. Um, just my enthusiasm, maybe. You know, if I seem interested in the students or excited about the subject. Maybe voice tone, volume.

I: Okay. Um, what’s the value of assessing yourself and not just relying on an administrator? (Reference: P1, S2, I0, Paragraph 129)

Notice that the interviewee challenges the student to consider her decision to use an outside observer’s evaluation versus self-assessment.

Type 13: Interviewer asks the student to confront a naïve aspect of one’s reasoning

ATLAS.ti Code: P3B T asks confronting Q (S learning)

Description: From the perspective of the interviewer (I), the student (S) is somewhat "caught" in this case. The student is "caught" in that he or she has conveyed contradictory comments or remarks that fail to consider an important drawback, concern, benefit or opposing view. Interestingly, prior to this move by the interviewer, the student may or may not be aware of any insufficiencies in his or her responses. The interviewer then makes a move to challenge the student to consider hidden complexities in the situation under study. For instance, after a student conveys that he or she thinks praise is important, the interviewer asks, "You mentioned how you think praise in a large group setting is important to consider. How would use of global praise detract from promotion of your goal—students will develop a sense of intrinsic motivation?" This code is distinguishable from "Confronting Q (S evades)" based upon how successful the interviewer is at bringing the student to face insufficiencies in their response. If the student effectively evades recognition of insufficiencies, then the code selection is "Confronting Q (S evades)."
Exemplar: T asks confronting Q (S learning)

Rationale for Code Selection
Notice that the interviewer has asked the student to describe the role of the teacher during a group activity and the student struggles to explain her role.

I: What else could you do when [the students] are working in these cooperative groups?
S: [long pause] Maybe...I'm not sure. I wouldn't really want to give them answers. I mean I want to guide them and give them some direction. Well, if I'm working with them, I'm working with them for a reason. Um, you know, maybe they're doing something that's...or that I wouldn't want them to be doing by themselves, you know, something that requires mastery or something like that, but I don't know. Maybe help them with their—not just the content that they're learning, but with their team building or...

I: So what does it mean that you have a really easy time generating twelve to fifteen strategies that the kids are going to do, but you really struggle when it comes to what you're going to do?
S: [long pause] I don't know. I don't think I have, like, a firm grasp on what I'm really supposed to do. (Reference: P1 S2 10, Paragraph 44)

Type 14: Use of a critical incident to better diagnose student thinking
ATLAS.ti Code: P4A T Critical incident (effective diagnostic)
Code frequency across participants = 15

Description: In this case, a critical incident is used to initiate a line of questioning to better diagnose student (S) thinking. The line of questioning is generally not extremely lengthy and may shift abruptly for good reason because the student responds credibly to the scenario that is posed. In order for this code to apply, evidence must exist to support that no further questioning is needed given the student's credible response(s).

Exemplar: T Critical incident (effective diagnostic)
Rationale for Code Selection

Interviewer (I): So let's say that you are the new third grade teacher. How would you decide what content to teach your students?
S: First, I would look at the school's curriculum...what I am expected to accomplish that year--that would be the first step, you know, asking the administration what they expect of me. And then probably, I would talk to maybe the second grade teacher to see what they learned the previous year before or even first grade to see how far they got or what they worked on, so that I don't repeat a lot of the content. And you know, see how they teach science, I mean, do they teach them the scientific method or you know, or what kind of things do I have to maybe not, you know, rework with them? And then I would probably do some assessing of their misconceptions like we did [in class] when you had us draw a picture. You know, maybe have them draw a picture--like in third grade, if they are not good at writing, then maybe they could verbalize to me, what do you know about the water cycle or tell me what you know about rain or other different concepts, you know. And just assess them that way and see kind of where they are at and maybe look at their ITBS scores to see how they are doing like science-wise. Um, you know, just ask them the first day, what do you guys want to do in science? You know like, what is stuff that they are interested in, that they would like to do. I like letting the students have input--not necessarily that you have to use all of it, but if there is something that they are really interested in, I think that they are going to want to learn it more if they want to do something so, you know, find a way to tie it into how you want to teach.

I: So let's say the curriculum committee is changing around what topics are being taught at each grade level and you are the new third grade teacher. They come to you and say, "You know, we were thinking about putting atoms and molecules and surface tension in the third grade curriculum." How would you respond to that?

S: I would tell them that I absolutely do not agree--that third graders are right at that age when they are between those two stages of concrete and formal. They are in the concrete operational stage...They are not going to be able...
to understand surface tension and atoms and it is going to be of no use to them. It is not going to teach, I mean it will teach them to maybe memorize terms and I don’t think that you know as a science teacher I want, I am more interested in the students thought processes not whether they can memorize. I am more interested in, um, how they can think through a problem and how they can independently solve a problem, than I am about how much they can memorize. I can bring in Piaget’s developmental theory if they want proof of that. Um, or other developmental theorists to prove my point...

I: So let’s suppose that you are in your first year of teaching and you have an angry parent that says, “You know, my kid comes home everyday and just is a little upset because um, she is working in this group all the time. You know, back in my day, we used to do everything on our own. We didn’t need the other kids to help us. We would do everything on our own and turn it into the teacher and we were done. How would you respond to this parent? (Reference: P1 S3 116, Paragraph 11)
importance of using effective questions and student discomfort. Overall, the student has not conveyed an understanding of the synergistic relationship amongst teacher behaviors (questioning, coupled with appropriate wait time, encouraging responding behaviors, and inviting non-verbal behaviors). The concern here is that if the student fails when attempting to conduct class discussions, she may lack the knowledge to systematically evaluate all pertinent aspects of her practice, and thus, discard using class discussion as a strategy because it just “doesn’t work for her.” Notice then the interviewer shifts the questioning toward a concrete experience.

guess. Might be a yes/no question maybe. Um, the question might be over their heads. They might not be able to understand it, or maybe the kids just ah are too nervous to participate. That can be part of it, too. Um, I don’t know.
I: What other things might you do which might make a kid not want to answer a question?
S: Ah, I don’t know. Maybe the way I’m teaching, or if I’m standing in front of the room like calling on someone in front of everybody else—like having them answer a question. I know myself I get choked up when teachers do that sometimes. Um, ...
I: What am I doing right now that is keeping the stress level as low as possible in what some students could perceive as a high stress situation?
S: Giving me time to think about it. Giving me wait time I guess.
I: Ah-huh, what else am I doing? I didn’t just use wait time there.
S: What else are you doing? Um, well, you are giving me time to formulate my response. You are sitting in a way that isn’t real intimidating I guess.
I: And so how am I sitting that actually reduces pressure?
S: Well, you’re sitting pretty relaxed I mean it’s different than someone sitting behind a desk looking at you, asking you questions.
I: Where am I facing?
S: At the wall.
I: Where am I looking?
S: You’re looking at me sometimes, but sometimes not. You’re looking at my eyes.
I: But it shifts. I’m using very non-direct eye contact. Um, all of these things, keep in mind, are going to be part of your repertoire as you teach. So, if you ask a good question, there are other things that have to go along with that good question. It’s a very different situation in a classroom environment where I’ve got a group of kids and I want to put pressure on them to participate. So, what
kinds of non-verbals would I need to use along with my good question to put pressure on kids to start talking?

S: Well, I know one thing you did a lot of times in class was you would sit with us and then kind of walk around while we were in groups talking, but you wouldn't like stand there right next to us the whole time we were talking or anything like that. Um, I might be missing what we are talking about here.

I: So if I'm trying to cut stress right now and if I'm in a classroom where I'm trying to put pressure on kids to participate, I'm going to have to do some of the opposite non-verbals to what I'm doing now. So, how would I sit, where would I look, what kinds of things would I do?

S: You would kinda sit off maybe in the corner and take notes, maybe like you are doing right now. Like you would write down some of the things that we are saying in our groups. Um, I don't know—if things aren't going so well, you might ask another question, a different question to kind of...

I: Let's put a twist on the scenario. Let's suppose I ask a great question and I use my wait time. And I get kid #1 to start answering. The kid's done answering and everybody looks at me. Well, I'm trying to get a class discussion going, not just a teacher to student, teacher to student discussion. I want to get another kid to now talk. What can I do to get another kid to talk when this first kid has just responded, and now everybody is just looking at me without me having to say anything? If I say anything, it's not a kid to kid discussion.

S: I don't know. You've got me stumped.

I: Okay, that's fine. So one of the things that I have to do now is figure out how I can use my non-verbals to put pressure on students. I want to get another kid to pipe up. What type of child is going to be most likely to pick up on this conversation?

S: Pick up on... you mean answer the next question?

I: No, not the next question, but [try to] build off of what the first kid just said, and contribute another idea.
Now, the student is starting to consider new ideas here, such as carefully directing her eye contact.

Here again the student appears to have "bottomed out" because she is repetitive.

Notice that the interviewer now provides some explanation after "a need to know" has been created.

S: So he knows what's going on.
I: So, who do I look at?
S: You look at the kid that you know might know what's going on.
I: To get that pattern established in this student to student discussion. I'm going to start looking at those kids that are most likely to pick up on this. I'm going to be using very direct eye contact and very raised eyebrows because every kid is looking at me and I want to look back at them and get them to start picking up on this. But, if I'm sitting and slouching like this, they're probably going to perceive that I'm not interested—that I've gone off in a coma. How do I convey to these kids that it's their turn to talk? Eye contact is a piece of this, but it can't be used alone. What other non-verbal behaviors can I do to get kid #2 and 3 and 4 to start talking?
S: Well, you might--I don't know--kind of sit off and, you know, act interested and, like you said, look at kids that you would hope would be the next one to answer. I mean act interested like you want to know the next answer to a question.
I: And here's also where hand gestures can play a role because sometimes when kids, you know, they literally handed the "ball" to me when they all look at me. Now they are waiting for me to respond to this kid's response. But I'm going to hand it back to them, so all I have to do is--and this open hand moving from place to place indicates that there are more ideas out there and that I want [students] to contribute. So I could do this all non-verbally, while, again, sitting forward, looking at students very expectantly with the eyebrows up, making eye contact to my next "most likely to talk" kids, and getting them started into it. Now, we've got that pattern going. Now, I start targeting my quiet students and staring them down trying to get them to contribute ideas. There are some other strategies you might have to employ if I have really hesitant kids...I'm going to add additional supports rather than take away the expectation so, you know,
Type 16: Use of a critical incident to better diagnosis and create a learning experience for the student

ATLAS.ti Code: P4B T Critical incident (teaching tool)

Description: In this case, a critical incident is used to initiate a line of questioning to better diagnose a student’s thinking and create a learning experience for the student. The interviewer (I) selects a critical incident that the student (S) will very likely encounter in practice, such as working with a colleague or responding to a parent’s question; however, the scenario that the interviewer constructs is not an extreme situation that is overwhelming to the student (ATLAS.ti Code: Critical incident (extreme case)). This line of questioning is subtle and, thus, can distract the student from the topic under study and the struggles the student was having previously. The student's response to this question becomes fodder for further questioning and generally a series of linked questions is used. In this case, student learning is evident.

Exemplar: T Critical incident (teaching tool)

Rationale for Code Selection

I: So let’s suppose that you’re teaching first graders and you’ve got a corner of your room where you have lots of big magnifying glasses and hand lenses and things, and the kids bring in things that they find outside. And it’s kind of a learning center area and they just go and grab hand lenses and take a look at them. And let’s suppose that the Intel Computer Company comes in and wants to offer you a set of computers with microscopes that you plug into the computers and you get a full microscope view. But the nice thing about them is they don’t have any knobs so the kids don’t have to worry about trying to focus the things. They don’t have to look through the little view finder. You just stick it underneath there and on the computer screen you could see the item fully magnified like a microscope view of whatever it is you put under there. They do exist. I have one of these at home. And, in exchange, they want to take your hand lenses and replace them with this computer based microscope. How would
The student doesn’t recognize the importance of developmental learning theory in deciding whether or not to take the computerized microscope.

The student only mentions advantages related to using the computerized microscope in her classroom. The interviewer prompts her to consider possible disadvantages.

The student still isn’t considering developmental learning theory.

The interviewer prompts the student to consider learning theory, in general.

you decide whether to take them up on their offer or not?
S: Do the kids have to do anything with the computer – like it’s basically...?
I: Put the object under there and it works automatically...
S: It lets them see it. Truthfully, I think that would be awesome – a great thing to have in the classroom, um, just through the technology that they are experiencing, I mean, as first graders. When I was a first grader there would probably be the hand lens that I would be able to work with, which is good to let them have, too. But I think as times are changing, this computer technology which allows them just to sit there and put whatever they want under the microscope...that’s great. I think having to focus and having to mess with this and do it right and do all that will take away a lot from the kid. It will cause a lot of uninterested students. It takes too much time to do and they don’t know how to do it. I think the technology based microscope can open their minds a lot more. And then, too, you know, using that type of technology would help you to incorporate more in your classroom, too.
I: What are some potential problems that might exist in getting rid of your hand lens and using computer based microscope?
S: I mean I don’t really know a lot about other computer based microscopes, but, um, obviously you couldn’t take it places. You couldn’t you know take it outside. You’d have to bring the objects to the computer.
I: What about what we know about how kids learn might raise some issues that we have to take into account here?
S: Well, um, having the hand held lenses makes--just makes me--the first thing I think of is having the kids going outside and doing it on their own. Just being able to go outside and look at the leaves on the trees and not having to bring the leaves from the trees into the classroom. Because you’re not going to be able to bring everything in the classroom that you want to look under the microscope. And having them be able to explore and be creative with what they want to look under the
Notice how the interviewer prompts the student to consider how first graders reason (in view of developmental learning theory).

Notice here that the student says, "But I think it’s good for them to see that." While she has been asked to consider both advantages and disadvantages of using the microscope, she clings in the end to her original decision.

Notice that many linked questions have been asked to this point.

Here the interviewer asks a confronting question. The student's response shows that she is not sure if her previous idea holds strong under scrutiny.

microscope. I mean, yah, I can see how it can be hindered if it is just in the classroom. You have to stay here to look at what’s in here and bring whatever to the computer.  
I: So let’s suppose that a kid brings in a leaf and puts it under this computer microscope. And on the screen they see cells. What might be some things that you’d really have to be careful of here?  
S: As first graders, it’s really in-depth material.  
I: How so?  
S: Um, I’m really not familiar with the first grade content, you know, what they can and can’t learn. But, you know, I remember learning cells in biology, about cells and leaves and all that. And as first graders it’s, well, beyond their level of learning.  
I: What do you know about first grade thinkers? You don’t have to know what content is out there. You just have to know how they reason and what they think.  
S: It’s very simple. It’s not complex at all. They won’t understand that, I’m not saying they won’t understand, but it’s hard for them to understand the cells and you know what makes a leaf breathe and it’s a complex process for first graders to understand. But I think it’s good for them to see that.  
I: What is the level of development of these kids?  
S: It’s pre-operational. It’s very simple, very low.  
I: So what are they going to have a hard time understanding?  
S: Understanding where it even is. I mean understanding that--I mean to them, they see a green leaf. They see this leaf. I mean, it doesn’t mean--they don’t really think that it grows from the ground and it blossoms and reproduces. That’s just a lot for them to comprehend and they don’t--they see that this leaf has cells inside it.  
I: Or can they?  
S: Through the microscope? Well, if they did see cells, they might not even be able to.  
I: And there’s the rub because if you’ve got a kid who is pre-operational and even concrete, if they can’t physically
The interviewer elaborates on the student’s quandary about the level of abstraction that first graders can understand. 

see it with their naked eye they’re going to have a hard time understanding that it exists. And so if you put a leaf under there, if you can put a leaf under a hand lens it’s just a bigger leaf and they are going to see more detail. But it’s detail that they can still make out just by looking at it with the naked eye. And so they can understand that. They’ve got to have that experience with the very concrete using the hand lenses for a very long time before they can even work up to using the regular microscope. The problem with the computer microscopes is that they are even more abstract than the real ones. When you give a seventh grade kid a real microscope, they need the experience of turning the knob and seeing the focus change. Seeing the object underneath there looking through and looking down at the object because as soon as you now transfer to a screen that’s another level of abstraction--that’s what’s under here is what’s on there. What’s on the screen tends not to be real. They’re inundated with television and things like that which you can’t touch. They’re not real. And now you put something underneath over here and it shows up over here and it looks different than what’s under there. So if they all of a sudden see cells, they’re not going to think that that’s a magnified version of what’s underneath there because they can’t physically see that. So we’ve got two levels of abstraction there, one is the actual magnification is way too high, but the second issue is the screen, too, you know, just the location of where they are seeing the image really can tangle them up. Personally I’d keep the hand lenses for a first grade kid and save the microscopes for the seventh grade and save these computer based ones until high school. (Reference: P1 S6 I5, Paragraph 36) 

I: So let’s assume that you take a job in inner city St. Louis where all your kids are on the free lunch program and they come in without having eaten breakfast, and only 30% of them are reading at grade level. How are you going to know if you are effective in that environment?
Notice that the student talks only of using student achievement or progress.

S: Ah, well, if the kids are making progress, I mean I would hope that to see that the kids are making progress from where they’re at in their reading ability, in other classes too. Um ...

I: And there is high need for special education services down there and [the students’] progress is pretty slow.
S: Ah, oh, that’s tough.

I: And some of their progress goes backwards. Dad gets killed in a gang fight half way through the school year and the kid actually sees it happen. I had this happen [in my own teaching]. [Students] will actually regress in their understanding for several months.
S: That seems really tough to know that, you know, you have kids that are going backwards instead of doing the right thing. I don’t know how you assess that.

I: Here’s a crazy comparison. Well, actually it’s not that crazy. If we look at medical doctors—if we were to assess doctors by looking at their patients, cancer doctors, emergency room doctors, heart doctors would be our worst. They would all get “F’s” and be fired, but our OB/GYNs would be our best because their patients actually double in number if they are successful. So, you know, none of these people die. They actually produce another human being so they’re success rates would be even better than 100%. So, we can’t judge a doctor by looking at their patients. Likewise where we certainly assess our students to see how well their doing, we don’t assess our students to see how well we are doing as teachers. We’ve got to look for other measures because kids aren’t all the same. They’re going to have different backgrounds, different prior knowledge, different access to resources, different parents at home who give them different amounts of communication and food and all these different things that impact this kid’s learning, and likewise, it’s not just the bottom of the barrel that I’m talking about. You could be in [a university setting] where all your kids are professors’ kids and your kids do extremely well and you could think, ah, it’s all because of...
Notice that the student now recognizes the importance of basing effectiveness—be it doctor or teacher-related—on research-supported practice.

Notice that the student now recognizes the importance of basing effectiveness—be it doctor or teacher-related—on research-supported practice.

my wonderful teaching when, in fact, you may be mediocre at best. So how do we find out where our effective teachers are despite these differences in students? S: Well, I guess when you were talking about doctors, you’re a doctor that deals with cancer and stuff like that and you have people die, you’re doing what research shows is the best possible method to give that person a chance at living. Um, I guess you can apply that to doing what research shows is the most effective way of helping kids learn. (Reference: P1 S7 I5, Paragraph 101)

Type 17: Interviewer asks a series of questions that are subtly related and culminate in asking the student to revisit contradictory ideas

ATLAS.ti Code: P4C T Diverge/Reconverge

Description: In this case, the interviewer (I) has asked the student an initiatory question, the student has responded and the interviewer considers the student’s answer as insufficient and/or inaccurate. The interviewer then asks the student a line of linked questions that seem unrelated to the original, initiatory question. Suddenly, through this line of questioning, the student (S) now conveys information that addresses the original question. The interviewer then instructs the student to return to the original question and use what he or she stated previously to revisit the original question in a more informed manner. This questioning strategy generates a great deal of student learning as the student has difficulty dismissing what he or she stated previously.

Exemplar: T Diverge/Reconverge

Rationale for Code Selection

Notice that the interviewer asks about responding to a student after he or she conveys an incorrect idea.

I: So if the students gave you an answer that wasn’t quite right, how would you want to respond to that student? S: I definitely wouldn’t want to tell them, you’re wrong! And maybe if it was at the beginning of the unit, I would tell them that we are going to take a good look into that and see what we can find out about it and just kind of leave it as something for them to look into and that we could look into together as a class. And maybe even if it wasn’t part of what I was planning to teach, you know, I would definitely want to make that part of it now, so that,
Now the interviewer shifts the line of questioning to consider how to respond when a student conveys a correct idea.

because maybe if she or he is thinking of it, then maybe other students have that misconception also.
I: How would you want to respond to a student to give you a correct response?
S: I know, in my practicum, I would right away say, you’re right! But I know I wouldn’t want to do that.
I: Why don’t you want to do that?
S: well, I want them--I don’t want to do that because if I say that’s right for one student, they are always going to be looking for me to say, yes, that’s right or good job, and they are just going to become where they’re just going to answer questions to hear that. And I want them to not strive for my positive reinforcement.
I: So how would you want to respond?
S: I would take some of the modeling that you have showed us in-class. Just kind of nodding my head or asking if anyone else had any other ideas.
I: Why would you ask that?
S: Because perhaps they were kind of right, but maybe someone else has another idea and if I say that they were right, then it would shut off any other answers that are going to come from the class. If students think there are still more out there, they’re going to come up with more ideas instead of thinking, well, I’ve answered it correctly.

Now we can move on to the next question.
I: So it seems you’re going to respond to students in a different way whether they are right or wrong. What message might that send to your students?
S: That if I would respond to them if they were right or wrong? Or that I am?
I: Well, you said that you would respond to students--if they were wrong, you would say, "Well, maybe we can go look that up or maybe we will find out more about that later." And then you said, "Well, if they’re right, I would say, okay, or I’d say, “Well, what do the rest of you think?”
S: Okay.
I: So if you are responding to a person if they’re either
wrong or right—if you are responding differently—what message would that send to your students?
S: Well, [pause] I look at it in kind of two different ways. If I respond to them—we can go to look that up together—that would be conveying it's okay if you didn't get that and that that's an interesting point to find out more about. But I also wouldn't want them to catch on to a pattern from me about whether they're right or wrong.
I: Why wouldn't you want your students to pick up on a pattern?
S: Because then it is just like saying, you're right, or you're wrong. I would also say, "What do the rest of you think?" if someone answers wrong, too. I should add that.
(Reference: P2 S4 I18, Paragraph 74)

Organizing Codes in Order of Sophistication

In an effort to display the data purposefully, the codes were arranged in order of sophistication. In this case, sophistication was judged based on the two-fold purpose of an oral defense—to both evaluate and create a learning experience for the student. Decisions that reflected more (or less) evidence of fulfilling these two purposes were considered more (or less) sophisticated. Clusters of codes that were similar in sophistication were created and labeled using phrases, such as "somewhat sophisticated," and "highly sophisticated." Two separate organizations of codes were created; one regarding the codes pertaining to the participants' use of explanation and the other pertaining to the participants' use of probing questions. To flush out specific details regarding the organization of codes for explanation and probing, respectively, the following rationales are pertinent.
Rationale for Organization of Coding Scheme (Category 1: Explaining). The four codes regarding the participants' use of explanation during an oral defense were arranged in order of increasing sophistication with some types designated as equally sophisticated. This continuum is shown below:

**Least sophisticated**
Type 1: Explanation offered with little probing

**Somewhat sophisticated**
Type 2: Explanation after attempting to teach through scaffolding  
Type 3: Explanation after asking a series of probing questions and the student is unable to answer

**Sophisticated**
Type 4: Explanation coupled with the interviewer asking a series of linked, probing questions

The first code regarding explanation is designated as the least sophisticated because the interviewer opts to avoid the cognitive challenge associated with posing any probing questions. While conveying information to a student is certainly important, there is no evidence to conclude that the student became at all dissatisfied with his or her previous response(s), and, thus, is likely to be less receptive to processing new information via explanation from the instructor. Researchers who have studied learning as a process of conceptual change assert that students may likely misunderstand information that is conveyed to them through explanation as they filter incoming information through their previous ideas. The second and third
codes are designated as equally sophisticated. Collectively, these two types are more sophisticated than the first one because now evidence exists to conclude that the interviewer is trying to make students more aware of deficiencies in their responses through the use of probing questions. However, the interviewer is not as successful as is evident in the code associated with a sophisticated designation where more linked questions are posed and more evidence exists to conclude that students recognize that their previous ideas were errant and/or incomplete.

**Rationale for Organization of Coding Scheme (Category 2: Probing Questions).** The overriding idea that was considered when creating this scheme focused on the extent to which the decision appeared to create a learning opportunity for the student. The codes are grouped into four clusters identified as least sophisticated, somewhat sophisticated, sophisticated, or highly sophisticated probing:

- **Least sophisticated**
  - Type 1: Interviewer chooses not to ask any probing questions
  - Type 2: Interviewer shows difficulty when attempting to construct a probing question
  - Type 3: Interviewer asks similar, successive questions

- **Somewhat Sophisticated**
  - Type 4: Interviewer offers feedback by listing ideas the student has mentioned and then asks for more information
  - Type 5: Interviewer probes a student’s vague use of terminology by asking the student to explain a term further
Type 6: Interviewer probes whether a student can articulate how to apply knowledge
Type 7: Interviewer attempts to confront student’s ideas, but the student evades the confrontation
Type 8: Use of a critical incident involving an extremely challenging scenario
Type 9: Use of a critical incident is underdeveloped (truncated line of questioning)
Type 10: Interviewer attempts to use scaffolding to create a learning experience, but the result is less effective

Sophisticated
Type 11: Interviewer shifts focus of questioning to an important “link”
Type 12: Interviewer probes whether the student can further articulate a rationale for a decision
Type 13: Interviewer asks the student to confront a naïve aspect of one’s reasoning

Highly sophisticated
Type 14: Use of a critical incident to better diagnose student thinking
Type 15: Use of a concrete experience within a series of linked questions that are designed to create a learning experience for the student
Type 16: Use of a critical incident to better diagnosis and create a learning experience for the student
Type 17: Interviewer asks a series of questions that are subtly related and culminate in asking the student to revisit contradictory ideas

The first codes (Types 1-3) are designated as least sophisticated decisions because these moves rarely created a learning opportunity for the student. The terminology least sophisticated may be somewhat misleading and should be considered carefully. For instance, asking the student to bring forward more information by asking, “What else would you consider?” may be useful when trying to ascertain that the student has offered as much as possible on a topic. However, this group of
moves overall is characteristic because it appears the interviewer is struggling to shape questions that tend to increase the likelihood of student learning. The next cluster of codes (Types 4-10) is designated as somewhat sophisticated decision-making while the next three codes (Types 11-13) are classified as sophisticated decision-making. Both of these clusters are different from the previous one (least sophisticated decision-making) because of the effort invested by the interviewer in constructing follow-up question(s) for students to address. The break between these two clusters is based upon the extent to which the moves under study contributed to creating a feeling of dissatisfaction within the student regarding the accuracy and sufficiency (or lack thereof) of their previous ideas. Generally, for the group of categories labeled as "sophisticated," the moves under study tended to create more dissatisfaction in the student regarding the effectiveness of their previous ideas. The last four codes (Types 14-17) compose a group designated as "highly sophisticated decision-making." This group is characterized by the interviewer considering a great deal of information at once and constructing lengthier, linked lines of questioning that result more often in student learning. Within each cluster, some codes are designated as equally sophisticated.
Display of Frequencies—Tables and Graphs

After completing the coding process and organizing the codes by sophistication, the frequencies associated with each code were recorded. Frequencies were calculated for each code per semester per participant. In general, the frequency data associated with each code are displayed in this section in two different ways. First, the raw numbers are displayed in tables. Second, the raw numbers were used to construct graphs plotting frequencies versus semester(s) of experience for each participant. The tables and graphs below are organized according to whether they pertain to data regarding the participants' use of explanation or data pertaining to the participants' use of probing questions.

Specifically, frequencies related to the participants' decision-making when using explanation are listed in Tables 4-6.
Table 4. Frequencies of explanations—Joanne

<table>
<thead>
<tr>
<th>Teacher Decision Related to Explanation</th>
<th>Semester(s) of Experience</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>E1 A T Explanation w/o much probing</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total of least sophisticated T decisions (explaining)</strong> =</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>E2 A Explanation with attempted scaffolding</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E2 A T Explanation after S &quot;bottoms&quot;</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total of somewhat sophisticated T decisions (explaining)</strong> =</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>E3 A T Explanation coupled with scaffolding</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total of sophisticated T decisions (explaining)</strong> =</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5. Frequencies of explanations—Andrea

<table>
<thead>
<tr>
<th>Teacher Decision Related to Explanation</th>
<th>Semester(s) of Experience</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>E1 A T Explanation w/o much probing</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total of least sophisticated T decisions (explaining)</strong> =</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E2 A Explanation with attempted scaffolding</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>E2 A T Explanation after S &quot;bottoms&quot;</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total of somewhat sophisticated T decisions (explaining)</strong> =</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>E3 A T Explanation coupled with scaffolding</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total of sophisticated T decisions (explaining)</strong> =</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 6. Frequencies of explanations--Crystal.

<table>
<thead>
<tr>
<th>Teacher Decision Related to Explanation</th>
<th>Semester(s) of Experience</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>E1A T Explanation w/o much probing</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total of least sophisticated T decisions (explaining)</strong> =</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E2A Explanation with attempted scaffolding</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>E2A T Explanation after S &quot;bottoms&quot;</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total of somewhat sophisticated T decisions (explaining)</strong> =</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>E3A T Explanation coupled with scaffolding</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total of sophisticated T decisions (explaining)</strong> =</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Using data listed in the tables above, graphs were constructed of frequencies per semester(s) of experience. Figures 1-3 display the frequencies for explanation by Joanne, Andrea and Crystal, respectively. Figures 4-6 display the participants' frequencies for each different level of sophistication. When examining these graphs (Figures 1-6), it is helpful to consider carefully what is represented by a single data point in any figure: Each data point per semester refers to the frequency of an observed move after coding the behaviors of each participant during four oral defenses (6 hours of time spent interviewing methods students).
Figure 1. Display of Joanne's use of explanation across semesters.

Figure 2. Display of Andrea's use of explanation across semesters.
Figure 3. Display of Crystal’s use of explanation across semesters

Figure 4. Display of least sophisticated explanation—All participants
Frequencies related to the participants’ decision-making when asking probing questions are listed in Tables 7-9.
Table 7. Frequencies of probing questions—Joanne

<table>
<thead>
<tr>
<th>Teacher Decision Related to Probing</th>
<th>Semester(s) of Experience</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>P1A T No probing Qs</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>P1B T Minor struggles (stutters, embedded Qs, etc.)</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>P1C T Repetitive Qs (similar in cognitive demand)</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>P1D T takes inventory of responses (what else?)</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total of less sophisticated T decisions (probing)</strong></td>
<td><strong>38</strong></td>
<td><strong>22</strong></td>
</tr>
<tr>
<td>P2A S Vague on term use/T probes</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>P2B S Vague on application/T probes</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>P2C T asks Confronting Q (S evades)</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>P2C T Critical incident (extreme case)</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>P2C T Critical incident (truncated questioning)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>P2C T Scaffolding attempt (less effective)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total of somewhat sophisticated T decisions (probing)</strong></td>
<td><strong>27</strong></td>
<td><strong>20</strong></td>
</tr>
<tr>
<td>P3A S Missing an important “link”/T shifts to “link”</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>P3A S Vague on rationale/T probes</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>P3B T asks confronting Q (finds a ’hole”)</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total of sophisticated T decisions (probing)</strong></td>
<td><strong>9</strong></td>
<td><strong>16</strong></td>
</tr>
<tr>
<td>P4A T Critical incident (effective diagnostic)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>P4B T Narrowing Qs (concrete experience)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P4C T Critical incident (teaching tool)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>P4D T Diverge/Reconverge</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total of highly sophisticated T decisions (probing)</strong></td>
<td><strong>1</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>
Table 8. Frequencies of probing questions—Andrea

<table>
<thead>
<tr>
<th>Teacher Decision Related to Probing</th>
<th>Semester(s) Experience</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>P1A T No probing Qs</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P1B T Minor struggles (stutters, embedded Qs, etc.)</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>P1C T Repetitive Qs (similar in cognitive demand)</td>
<td>29</td>
<td>23</td>
</tr>
<tr>
<td>P1D T takes inventory of responses (what else?)</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total of less sophisticated T decisions</strong> (probing) =</td>
<td>36</td>
<td>26</td>
</tr>
<tr>
<td>P2AS Vague on term use/T probes</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>P2B S Vague on application/T probes</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>P2C T asks Confronting Q (S evades)</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>P2C T Critical incident (extreme case)</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>P2C T Critical incident (truncated questioning)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>P2C T Scaffolding attempt (less effective)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total of somewhat sophisticated T decisions</strong> (probing) =</td>
<td>41</td>
<td>27</td>
</tr>
<tr>
<td>P3A S Missing an important” link”,/T shifts to “link”</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>P3A S Vague on rationale/T probes</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>P3B T asks confronting Q (finds a “hole”)</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total of sophisticated T decisions</strong> (probing) =</td>
<td>52</td>
<td>37</td>
</tr>
<tr>
<td>P4A T Critical incident (effective diagnostic)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>P4B T Narrowing Qs (concrete experience)</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>P4C T Critical incident (teaching tool)</td>
<td>29</td>
<td>23</td>
</tr>
<tr>
<td>P4D T Diverge/Reconverge</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total of highly sophisticated T decisions</strong> (probing) =</td>
<td>36</td>
<td>26</td>
</tr>
</tbody>
</table>
Table 9. Frequencies of probing questions—Crystal

<table>
<thead>
<tr>
<th>Teacher Decision Related to Probing</th>
<th>Semester(s) of Experience</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>P1A T No probing Qs</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>P1B T Minor struggles (stutters, embedded Qs, etc.)</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>P1C T Repetitive Qs (similar in cognitive demand)</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>P1D T takes inventory of responses (what else?)</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total of less sophisticated T decisions</strong></td>
<td>30</td>
<td>17</td>
</tr>
</tbody>
</table>

- **P2AS** Vague on term use/T probes                      | 1  | 3  | 2  | 0  | 6  |
- **P2B S** Vague on application/T probes                  | 16 | 13 | 15 | 12 | 56 |
- **P2C T** asks Confronting Q (S evades)                  | 2  | 0  | 2  | 1  | 5  |
- **P2C T** Critical incident (extreme case)               | 5  | 2  | 0  | 0  | 7  |
- **P2C T** Critical incident (truncated questioning)     | 0  | 1  | 1  | 3  | 5  |
- **P2C T** Scaffolding attempt (less effective)           | 4  | 0  | 0  | 0  | 4  |
| **Total of somewhat sophisticated T decisions**           | 28 | 19 | 20 | 16 | 83 |

- **P3A S** Missing an important "link"/T shifts to "link"  | 17 | 14 | 22 | 20 | 73 |
- **P3A S** Vague on rationale/T probes                    | 6  | 1  | 8  | 8  | 23 |
- **P3B T** asks confronting Q (finds a "hole")           | 4  | 3  | 8  | 8  | 23 |
| **Total of sophisticated T decisions**                    | 27 | 18 | 38 | 36 | 119|

- **P4A T** Critical incident (effective diagnostic)       | 1  | 0  | 0  | 1  | 2  |
- **P4B T** Narrowing Qs (concrete experience)             | 1  | 0  | 2  | 2  | 5  |
- **P4C T** Critical incident (teaching tool)              | 1  | 1  | 5  | 3  | 15 |
- **P4D T** Diverge/Reconverge                            | 0  | 0  | 1  | 0  | 1  |
| **Total of highly sophisticated T decisions**             | 3  | 1  | 8  | 11 | 23 |

Graphs were created using the frequency data from Tables 7-9. These graphs are shown below as Figures 7-10.
Figure 7. Participants’ uses of least sophisticated probing questions

Figure 8. Participants’ uses of somewhat sophisticated probing questions
Figure 9. Participants’ uses of sophisticated probing questions

Figure 10. Participants’ uses of highly sophisticated probing questions
Display of Frequencies--Profiles

The second display of frequency data was in the form of profiles for each participant. Construction of profiles was initiated using observations recorded in research memos during the coding process. These observations supported the existence of certain tendencies per participant. For example, one observation that was recorded about Joanne was how she began to link more questions together as she gained experience conducting more oral defenses. In an effort to examine such observations more systematically, data from the coding process was displayed by constructing profiles. When constructing a profile, original interview transcripts were the main data source. Each transcript was printed with line numbers including code selections at various points in the interview. One new code was added within each transcript. The new code was a marker identifying any time an interviewer asked an initiatory question (e.g., how would you promote the goal of critical thinking in your classroom?). Further, all remaining codes pertaining to explaining or asking probing questions were combined into separate broad categories. For instance, all cases where the interviewer explained were designated with a marker for explanation, even if the forms of explanation exemplified differed in sophistication; all cases where the interviewer asked a probing question were
handled similarly with one exception. If a probing question was asked more than once, then the repetitious codes were each marked as a “repeated probe.”

In total, the designations that were marked were as follows: 1=initiatory question, 2=explaining, 3=probing question, 3.2=repeated probing question. Each designation was then associated with an approximate time of occurrence within an oral defense. Given that the transcripts did not reflect the actual time of occurrence when a move was made, line numbers in the interview transcripts were used to approximate the progress of the interview. Line numbers within the transcripts are a rough approximation of the length of an interview and the span of time within the interview when the interviewer asked an initiatory question, explained, etc. The count of line numbers associated with each interview overall was also recorded. To standardize the beginning and end of each interview in a profile, line numbers associated with each code (or marker) were converted into a ratio. The ratio was calculated by dividing the point at which a move was made (i.e., line number associated with asking an initiatory question, explaining or probing) by the line number count overall for the interview.

In this way, the beginning of an interview is designated with a “0” and the end of the interview is associated with a “1.” A value in between “0” and “1” is associated with a span of time during the course of the interview. For example, a
value of “0.1” represents a span of time when the interview was approximately one-tenth completed; a value of “0.9” represents a span of time when the interview was approximately nine-tenths completed. Graphs were then constructed by plotting each code designation versus the corresponding approximate time within the interview when a move occurred.

A series of profiles were constructed per participant. For Joanne, profiles were plotted using interview transcripts from four semesters of experience: Semesters 1, 3, 5, and 7. For Andrea, profiles were plotted using interview transcripts from three different semesters of experience: Semesters 1, 3, and 5. For Crystal, profiles were plotted for Semesters 1 and 3. One transcript was selected from each semester. All transcripts selected per participant involved interviews with students who earned similar grades in science methods (i.e., B+). Joanne’s profiles are shown together in Figures 11-14. Andrea’s profiles are shown together in Figures 15-17; and Crystal’s profiles are shown together in Figures 18-19.
Figure 11: Profile for Joanne—Semester 1

Figure 12: Profile for Joanne—Semester 3
The next two main sections present findings for each research question.

Findings for Research Question 1

The first research question explored how science teacher educators' practices changed over time as they conducted oral defenses with preservice teachers in a science methods course. Findings pertaining to this research question are divided into two groups: (1) Findings associated with how the participants used explanation and, (2) findings associated with how the participants used probing questions.

Findings associated with changes in the participants' practices when using explanation include:

- Finding 1: The participants preceded and followed their use of explanation with probing questions to different extents.
Progress of Interview

-•- Teacher Decision (1=initial question, 2=explain, 3=probe, 3.2=repeated probe)

Figure 15: Profile for Andrea—Semester 1

Progress of Interview

-•- Teacher Decision (1=initial question, 2=explain, 3=probe, 3.2=repeated probe)

Figure 16: Profile for Andrea—Semester 3
Progress of Interview

- Teacher Decision (1=initial question, 2=explain, 3=probe, 3.2=repeated probe)

Figure 17: Profile for Andrea—Semester 5

Progress of Interview

- Teacher Decision (1=initial question, 2=explain, 3=probe, 3.2=repeated probe)

Figure 18: Profile for Crystal—Semester 1
The next two main sections present findings for each research question.

**Findings for Research Question 1**

The first research question explored how science teacher educators' practices changed over time as they conducted oral defenses with preservice teachers in a science methods course. Findings pertaining to this research question are divided into two groups: (1) Findings associated with how the participants used explanation and, (2) findings associated with how the participants used probing questions.

Findings associated with changes in the participants' practices when using explanation include:

- **Finding 1:** The participants preceded and followed their use of explanation with probing questions to different extents.
• Finding 2: The participants’ use of explanation coupled with probing questions increased across semesters after an initial decrease.
• Finding 3: Lengths of the participants’ explanations varied by participant. Additionally, the participants’ lengths of explanations increased as they gained experience conducting oral defenses.
• Finding 4: The participants used explanation in more sophisticated ways as they gained experience conducting oral defenses.

Findings regarding how the participants’ used probing questions over time are as follows:

• Finding 5: In general, participants gradually improved over time in their abilities to promote meaningful learning using probing questions. However, at times, the participants struggled.
• Finding 6: The participants’ patterns of gradual improvement contained discontinuities.
• Finding 7: Evidence exists to suggest that a person can “plateau” and make little change in their practice over time.

Discussion of each of finding including supporting evidence follows. We begin with a discussion of the findings regarding explanation and then proceed with the findings regarding the participants’ use of probing questions.

Finding 1: The participants preceded and followed their use of explanation with probing questions to different extents.

When the participants used explanation, they did so at different times and coupled to different extents with probing questions. This finding is substantiated by the sheer existence of the codes, Types 2-4 for explanation, and the frequencies associated with each code. The frequencies in total associated with these three types of codes are substantial. In Tables 1, Joanne’s totals for Types 2, 3, and 4 are 11, 41,
and 24, respectively; in Table 2, Andrea’s totals are 2, 13, and 28, respectively; and in Table 3, Crystal’s totals are 4, 2, and 8, respectively.

Figure 4 displays the participants’ frequencies associated with times when they did not ask any probing questions before deciding to explain. Joanne’s frequencies increase slightly through semesters 1-3, peak in semester 4, and then decrease slightly in semesters 5-7. Data from Figure 5 assists in accounting for this pattern in Joanne’s data. In Figure 5, Joanne’s use of somewhat sophisticated explanation rises sharply in semester 4 from the previous semester as was observed in Figure 4. Perhaps Joanne was experimenting with her use of explanation, particularly during semesters 4-6. Andrea hardly ever decided to explain without probing students’ thinking first. Crystal’s data seems similar to Andrea’s; however, Crystal rarely used explanation (see Figures 4-6), especially in the first two semesters of experience.

Upon reflecting on this observation, I attribute this result to changes in my thinking at the time regarding the use of explanation in teaching. Coming from a strong background in the natural sciences as an undergraduate, I had experienced mainly lecture-based instruction. As a teacher, the notion that students might have preconceived ideas that could interfere with what I was explaining to them was foreign to me. During the time when I was teaching science methods, particularly in
semesters 1 and 2, I became conflicted about the use of explanation in teaching. While I was grappling with how to teach any subject more effectively—science or science methods—I believe I was shifting along a continuum of sorts. If teaching is considered as a continuum constructed with lecture (predominately teacher-generated explanations mainly) at one extreme and discovery learning (infrequent use of teacher-generated explanations) at the other, my view at that time had shifted away teaching using mainly teacher-generated explanations toward the other extreme. As such, I likely felt that in order for students to learn meaningfully, they had to piece information together on their own and my role was to provide them with opportunity, resources, managerial assistance, etc. Certainly if one holds this view, then one would infrequently use explanation as I exemplify, particularly in my first and second semesters of experience.

Analysis of the profiles constructed for each participant presents evidence to suggest that the participants shifted in how they chose to interweave probing questions with explanation. Figure 20 is a profile of Joanne during her first semester. This figure was constructed from Figure 11 with highlighted sections drawn in to aid in this discussion.
Notably, each time Joanne chose to use explanation in semester 1 as illustrated in Figure 20, the purpose was to close the discussion on one topic before shifting to another. In other words, each time she uses explanation she then shifts the direction of the interview to either a new initiatory question or the grade defense at the end of the interview. Joanne's profile in Figure 21 from her seventh semester of experience also shows evidence of this same use of explanation; however, highlighted sections in Figure 21 reveal an additional use of explanation that is markedly different. In Figure 21, Joanne's pattern now is one where she interweaves explanation with probing questions.
The repeated pattern highlighted at various times in Figure 21 is one where explanation is followed by a probing question. Arguably, this new pattern of interweaving explanation with probing questions is more sophisticated than the previous pattern. Joanne now recognizes that the student is missing some key information so she decides to convey that information to them. Then she evaluates whether the student can use the new information she conveyed by asking a related, probing question. In this way, Joanne is better able to evaluate how students are processing the information she conveyed via explanation than before when she did not tie her explanations to related, probing questions.
Andrea displays patterns in her use of explanation that are similar to Joanne. Andrea's profiles for her first and fifth semesters of experience with highlighted sections are shown in Figures 22 and 23. In Figure 22, Andrea chooses to explain ideas to students in seven instances; in five of the seven instances, she is shifting the interview to a new topic.

However, in Figure 23, Andrea interweaves explanation with probing questions repeatedly.
In contrast, Crystal tends to only use explanation to culminate a discussion on a topic. Figure 24 is a profile for Crystal from her third semester of explanation. Her use of explanation is similar to Joanne and Andrea in their first semesters of experience. Shifts in Joanne’s and Andrea’s use of explanation occurred after their third semester of experience. Perhaps Crystal has not yet reached enough semesters of experience for this pattern to occur.
Finding 2: The participants’ use of explanation coupled with probing questions increased across semesters after an initial decrease.

Figures 5 and 6 display the participants’ frequencies regarding somewhat sophisticated and sophisticated decision-making when using explanation. All codes displayed in these two graphs involve coupling explanation with asking probing questions. From one semester to another, the participants’ frequencies steadily increased after an initial drop. In Figure 5, Joanne’s frequencies steadily decrease in semesters 1 to 3, and then rebound in semester 4. Similarly, in Figure 6, Andrea’s frequencies follow this same pattern. This evidence is indicative of a pattern of decline just prior to a period of growth. This pattern shows evidence of what can be
expected when participants experiment with their practice and seek patterns to assist in predicting students’ responses, simultaneously reducing the cognitive demand associated with diagnosing student thinking.

Finding 3: Lengths of the participants’ explanations varied by participant. Additionally, the participants’ lengths of explanations increased as they gained experience conducting oral defenses.

Both Joanne and Andrea lengthened their explanations as they gained experience. If participants were intentional about improving their practice, one would expect their knowledge base to increase pertaining to course content; hence, they would have a more complex knowledge base from which to draw when constructing their explanations. Joanne’s explanations were lengthier than Andrea’s which is likely attributable to her more extensive experience teaching science methods. Notably, Joanne taught science methods for five years prior to conducting oral defenses whereas Andrea did not have any teaching experience in science methods before she conducted oral defenses. However, given the course emphasis on student thinking and helping students make connections, this finding appears to be somewhat contradictory. This issue will be explored in the section on Research Question 2.
Finding 4: The participants used explanation in more sophisticated ways as they gained experience conducting oral defenses.

Figure 6 displays the participants’ sophisticated use of explanation. Joanne steadily increases over time whereas Andrea’s pattern shows a relatively sharp increase after an initial decrease. Additionally, Figure 5 displays moves that are somewhat sophisticated, and again, Andrea’s pattern steadily decreases except this time she doesn’t show a rebound. Consideration of the data from Figures 5 and 6 simultaneously could account for trends in Andrea’s decision-making. A significant growth period appears to have occurred for Andrea near her fourth semester of experience. Joanne’s uses of somewhat sophisticated explanation are higher in Semesters 4, 5 and 7 as well. Together these observations provide evidence to suggest that a time of growth occurred in Andrea’s and Joanne’s uses of explanation during semesters 4 to 6.

Finding 5: In general, participants gradually improved over time in their abilities to promote meaningful learning using probing questions. However, at times, the participants struggled.

Overall, the participants improved in their abilities to create meaningful learning opportunities through asking probing questions. This finding is supported in multiple ways. In general, Figures 7 and 8 display evidence of making fewer mistakes (declining trends) and Figures 9 and 10 display evidence of more sophisticated decision-making (increasing trends) when probing students’ thinking.
Additionally, based on frequencies in Tables 7-9, the participants failed at times, especially in semesters when they were less experienced, to use more sophisticated probing even once in the course of a semester. One might think that failure to do so is due to a lack of opportunity. However, all students in the interviews from every semester were elementary methods students who were either one or two semesters from student teaching. Thus, similar opportunities to probe students’ thinking existed in each semester. However, the participants did not probe at times, especially earlier in their experience. This may have occurred because knowing how to probe students’ thinking in more sophisticated ways had not yet developed. In other words, when opportunities arose to probe students’ thinking, the participants likely were at a loss as to what to do.

Additional evidence of the participants’ struggles to design probing questions is notable upon examination of the profile data. Figure 25 contains highlights regarding probing (or lack thereof) from Joanne’s first semester of experience. At multiple points in the interview, Joanne asks an initiatory question, followed by one or two probing questions and then shifts to a new initiatory question. In one instance only, Joanne links a series of probing questions together. Further, midway through the interview, Joanne does not ask a single probe for a string of four different initiatory questions. However, evidence in Figure 26 suggests that, by her
seventh semester of experience, Joanne can now string a series of related probing questions together for different initiatory questions. The highlighted pattern in Figure 26 is one where Joanne asks an initiatory question followed by a probing question and then another probing question and then another, etc. More probing questions in succession are evident. Notably, this pattern appears only once in her profile for semester 1 (see Figure 25). Taken together, this evidence supports that Joanne had more difficulty designing probing questions when she was less experienced and that she improved in her ability to do so near her fourth semester of experience.
Evidence exists to support that Andrea struggled to construct probing questions as well. She struggled like Joanne in her first semester. However, Andrea’s struggle manifested differently from Joanne in one intriguing way. In the highlighted section of Figure 27, Andrea asks a string of seven probing questions. However, of these seven probing questions, all but two were unique; the rest were probing questions that she had asked previously (repeated probes=3.2). Arguably, Andrea senses that she needs to ask probing questions, but she is struggling as evidenced by the repetition in her questioning.
Finding 6: The participants' patterns of gradual improvement contained discontinuities.

Additional evidence exists to suggest that the participants' gradual improvement in asking probing questions was a struggle. In Figures 9 and 10, gradual trends of improvement are interrupted periodically by exceptions—characteristic "peaks" appear in declining trends and "valleys" appear in rising trends. These characteristic interruptions are the focus of this finding.

In Figures 9 and 10, both Crystal and Andrea show a "dip" in their use of probing questions from semester 1 to 2 before steadily improving their practice from that time forward. Similarly, in Figure 7, all three participants show an otherwise
steady decrease overall except for semester 3 where Andrea and Joanne made an unusually higher number of less sophisticated moves. In the discussion that follows, these unusually higher numbers of less sophisticated decision-making are attributed to two possible causes: (1) Differences in how the participants were mentored when preparing to conduct oral defenses, and (2) the effects of experimenting with one's practice in an effort to improve.

**Differences in Mentorship**

Prior to conducting any oral defenses, one is simply unaware of the inherent cognitive challenges for the interviewer. However, after one semester of conducting oral defenses, one can become anxiety-ridden about these challenges. While naiveté and over anxiety may account somewhat for regressions in the participants' practices when probing, this reason holds only to an extent. Notably, Joanne's development does not show a characteristic "plunge," as is evident for Crystal and Andrea (See Figure 9 and 10). A closer examination of differences in the participants' preparation for conducting oral defenses better accounts for these patterns of regression.

Both Andrea and Crystal were prepared by Joanne to conduct oral defenses; however, the preparation they received was slightly different from what Joanne received. Andrea and Crystal each observed Joanne conduct 4-5 oral defenses.
Joanne did not have the option to observe someone in practice given that no one was conducting oral defenses in elementary science methods prior to her decision to do so. Joanne had one session with a mentor whereas Andrea and Crystal had at least 4-5 sessions. Both Crystal and Andrea carefully attended to and physically recorded their observations while in the same room with Joanne as she conducted oral defenses. Specifically, Andrea and Crystal noted not only the initiatory questions that Joanne asked, but also the students' responses that warranted additional questioning and the corresponding probing questions that Joanne posed.

Additionally, Andrea commented that after observing Joanne conduct oral defenses, she carefully organized her notes from her observations in preparation for conducting oral defenses. As she did so, she created flow-charts of each initiatory question and subsequent follow-up questions that were useful given certain student responses. When asked to describe how frequently she referred to these flow-charts when conducting oral defenses the first semester, Andrea commented that she looked at this information frequently. In fact, she recalled once asking a student in an oral defense to wait for a moment while she "looked for" rather than "created" a follow-up question. During her second semester though, she tried to do more on her own. She set aside all of the flow-charts that she had created and attempted to design questions without them as she had observed Joanne doing.
Notably, Joanne had some prior experience conducting oral defenses before she mentored anyone; Andrea was mentored while Joanne was completing her fourth semester of experience and Crystal was mentored when Joanne was completing her fifth semester of experience. Comparatively, Joanne’s mentor had far more experience than she did as he had conducted oral defenses previously over the course of successive semesters in a four year span.

When observing a videotape of her mentor conducting an oral defense with a secondary methods student, Joanne remembers observing her mentor and being puzzled as to why he decided to do what he did. She noticed that he would begin questioning on one topic, shift the questioning to pursue a new line of questioning, and then suddenly redirect the questioning to the original topic broached some time ago.

Joanne realizes now that the “new” line of questioning that her mentor pursued was not completely unrelated to the original one. Her mentor used the “new” line of questioning purposefully as a way to confront contradictions in the student’s thinking. For instance, after stringing lines of seemingly unrelated questions together, Joanne observed her mentor ask the student to account for contradictions in ideas that he or she had just conveyed. Joanne recalls being baffled as to how her mentor created this sort of learning experience for the student.
Additionally, Joanne recognizes in retrospect that although she was given a large list of initiatory questions from her mentor that he used (see Chapter 3), she never asked certain questions on this list during an oral defense. She claims that she simply didn’t know how to credibly answer some of the questions herself, let alone discern the accuracy and sophistication of a student’s response. Joanne’s struggle with certain questions is further evident as she asked certain questions from the list when she was less experienced that she did not ask later on. She claims that she simply didn’t know how to probe the students’ thinking and, thus, discarded the questions that she could not productively use.

What might explain why Andrea and Crystal started out higher than Joanne in their use of more sophisticated probing questions? Both of them were told during their mentoring sessions with Joanne that they needed to ask probing questions for two important reasons: (1) to create more meaningful learning experiences for the student and, (2) to ensure that the student didn’t over-assess their understanding and performance in the methods class when it came time for the grade defense.

Interestingly, Andrea commented that in her first semester, she mostly asked probing questions involving critical incidents that she had observed Joanne use. She didn’t create her own questions. Instead, she used questions from her flow-chart that she had created from observing Joanne.
Although I wasn't as diligent about following Joanne's example, I did note that certain questions “should be” asked in certain circumstances. In this sense, in semester 1, Andrea and Crystal's decision-making was arguably mechanized. Joanne commented that she mechanically followed her mentor's example to a degree as well. Yet, while the participants' decision-making in their first semester was reasonably effective, especially for Andrea, they all felt they needed to change what they were doing to go forward. All three participants claim that after they conducted oral defenses their first semester, they discarded their “aids,” such as flow-charts and lists of questions, and determined to conduct oral defenses without a “crutch.” The result of setting aside one’s “crutch” corresponds to a period of less effective decision-making as one strives to improve. The characteristic “peaks” and “valleys” in Figures 7, 9 and 10, respectively, correspond to this time. Thus, important questions regarding mentorship before and throughout one's use of oral defenses across semesters deserves further consideration.

Effects of Experimenting with One's Practice

Discontinuities (i.e., “peaks” and “valleys”) in one's practice may also be accounted for when considering the experimentation that the participants were doing as they strived to improve their practice. A closer examination of practices
that occurred simultaneously when "peaks" and "valleys" were observed is warranted.

Joanne's teaching load was uncharacteristically higher in her third semester of experience than in any other semester. Correspondingly, Joanne made mistakes more frequently in her third semester. During this semester, she taught two sections of elementary science methods rather than one and conducted oral defenses with all her students; in total, she conducted 52 oral defenses in the last two weeks of the semester. The physical, emotional and mental exhaustion associated with a heavier course load may have predisposed Joanne to struggle more evidently. However, an evaluation of course load does not account for discontinuities in Andrea's practice. Andrea did not have a heavy course load like Joanne in her third semester of experience and as such, an excessive teaching load does not necessarily account for making an increased number of mistakes.

Patterns in both Andrea's and Joanne's practice may be attributable to the experimentation each participant was doing to improve their practice, particularly with regard to decision-making that is considered more sophisticated. For instance, when comparing Andrea's data in Figures 7 and 9 semester by semester, a "spike" in Andrea's pattern in Figure 7 related to least sophisticated probing occurs simultaneously with a higher frequency (n = 48) of sophisticated decision-making in
Figure 9, decidedly higher than the other two participants (Joanne, n = 32; Crystal, n = 38). In Joanne's case, when comparing her results from her third semester of experience (see Figures 7, 8, 9, and 10), Joanne's frequencies increase more sharply in all cases from semester 2 to 3 than for any other change. Further, in Figure 10, Joanne shows a dramatic increase in highly sophisticated decision-making immediately following semester 3. Arguably, the cognitive and emotional demands associated with trying to create situations where more learning occurs (more sophisticated decision-making) likely contributed to increased numbers of less sophisticated moves as well. Thus, experimenting with one's practice accounts reasonably for why the participants' steady patterns of improvement in their practice were interrupted by sudden increases in the mistakes they made.

**Finding 7: Evidence exists to suggest that a person can “plateau” and make little change in one's practice over time.**

In Figure 9, Joanne's practice improves steadily until the fourth semester when a plateau occurs and continues through the seventh semester, the last semester studied. This plateau effect is also present during these same semesters for Joanne in Figure 10. In a sense, one's ability to conduct oral defenses effectively seems negatively impacted by conducting them over a certain number of successive semesters. This is contrary to the notion that with increased experience comes improvement over time. As Joanne reflected on this observation, she considered
carefully what else was occurring in her professional life during the semesters associated with this plateau effect. She recalled that during these same semesters her professional responsibilities shifted to focus much more heavily on scholarship rather than teaching as the pressures of seeking tenure escalated. Admittedly, she dedicated less time to reflection on her teaching practice, but the same amount of time on preparation, teaching, and grading. This finding lends credence to the notion that while scholarship purports to expand what is known about how to teach effectively, an emphasis on scholarship does not come without expense.

Another possible explanation for the plateau phenomenon is interviewer burnout. Perhaps too many oral defenses (~120) become so routine that the interviewer is exhausted or simply hasn’t heard anything new in a very long time, resulting in automaticity and a decreased effort to improve.

**Summary of Results: Research Question 1**

Evidence exists to suggest that the participants gradually improved in their use of probing questions and explanation over time with periods of discontinuity and lack of improvement. Periods of discontinuity and lack of improvement were likely due to the struggle to improve one’s practice as well as the experiences one has with a mentor. Periods of little improvement can occur, and in this case, were likely due to scholarship over teaching or interviewer burnout. Mentorship from a
colleague who has comparable experience conducting oral defenses both before and throughout at least three semesters of experience is suggested to facilitate science teacher educators' development. Periods of growth in learning to conduct oral defenses as they are intended are most evident after three semesters of experience.

Findings for Research Question 2

While the previous results are arguably intriguing, one could claim that they are not at all unexpected. As teachers continue to teach, one would expect their practice to change. The meaningfulness of this study is accentuated when considering the results of the first research question in view of the second research question. The second question asks: How closely do science teacher educators conduct oral defenses in methods courses in ways that are consistent with advocated practices? First, clarification concerning what is meant by "advocated practices" is necessary. Second, the participants' decision-making will be reconsidered in view of how closely these developments reflect the practices advocated by the participants in the methods courses they taught.

All three participants made a claim at the beginning of each semester they taught concerning the standard for their teaching practice. The practices they expected themselves to exemplify should align with research on effective teaching and learning as well as promotion of goals generally agreed upon by the science
education community. The quotation below is taken from the course syllabi distributed by the participants to their students:

This course is intended to be a reflection of research on effective teaching congruent with consensus perspectives on human learning and goals for science education. If you sense discrepancies, you are expected to respectfully ask, “What is your rationale for....?”

Findings pertaining to the second research question are the following:

- **Finding 1:** Evidence exists to support that student thinking was consistently promoted by the participants’ questioning strategies.
- **Finding 2:** Evidence exists to support that the participants assisted students to see errors in their thinking.
- **Finding 3:** Evidence exists to suggest that the participants’ practices reflected careful implementation of the teacher’s role.
- **Finding 4:** All three participants show room to improve.

A description of each finding and supporting evidence follows.

**Finding 1: Evidence exists to support that student thinking was consistently promoted by the participants’ questioning strategies.**

The use of questioning by the participants is the strongest evidence to support this finding. When students are asked effective questions, they are invited to think and share their ideas. To what extent were the participants’ successful at getting students to think? A close examination of the actual dialogue between the participants and students assists in answering this question.

Given that similar initiatory questions were asked per semester for all participants, the student thinking that is attributable to initiatory questions is
constant overall. The most evidence to support how student thinking was promoted exists when examining how the participants used probing questions. Obviously, when the participants chose not to ask any follow-up questions after posing an initiatory question, students were given little feedback as to the credibility of their response and very little student thinking was promoted. Figure 28 shows the participants' patterns across semesters in terms of how frequently they asked an initiatory question and then opted not to ask any probing questions.

![Graph showing frequencies for no probing questions](image)

Figure 28. Frequencies for no probing questions—All participants

Notably, all three participants did not ask probing questions as often when they were less experienced. Andrea's pattern is quite low overall. When Joanne was
shown the data in Figure 28, she described why she felt she didn’t ask probing questions even though she sensed that she should. Joanne commented that when she was less experienced she remembers recognizing that students had misconceptions or incomplete ideas, but she simply didn’t know what to ask next. Not knowing what to do, she proceeded to a new initiatory question. From the student’s perspective, when an interviewer doesn’t ask any probing questions, the interview proceeds like a phone interview where the interviewer uses a list of questions, reads each question, listens to a response from the interviewee and proceeds to a new question. Perhaps students make new connections through constructing a response, but this seems highly unlikely. Further, when the interviewer fails to ask any probing questions, the student may perceive that his or her answer is sufficient and accurate when, in fact, it was not; thus, the participants better promoted student thinking when they utilized probing questions.

A second way that the interviewers promoted student thinking is through their use of questions involving critical incidents. A critical incident is a scenario that the students will likely encounter in practice. Typically, the students are not taken aback by the question because it resonates so clearly with their practicum experiences and previous experiences interacting with children. In this way, the line of questioning is subtle and can distract the student from the previous ideas under
study that the student was likely struggling to consider. The student's response to this question is used to frame further questioning and can lead to generation of multiple, linked questions. For example, substantial differences exist between the following two sets of probing questions (P1 S3 I22, Paragraph 67 versus P2 S3 I22, Paragraph 73) regarding selection of materials for use in a classroom:

I: So let's say that you have your content and your activities all together and now you want to decide what actual materials to use in your classroom. How would you make a decision about what materials are best to use?
S: I suppose on one hand you're going to have to go put yourself in the students' place and think about what they would want to use or what would they want to use to learn further.
I: What else would you consider?
S: For materials?
I: Uh-huh
S: I'm not sure. (Reference: P1 S3 I22, Paragraph 67)

The first question above (how would you make a decision about what materials...?) is broadly stated as an initiatory question is typically. The student responds by saying that she plans to use materials that the students "would want to use."

Notably, this student doesn't draw from learning theory in any way to make her selection. Implications of the students' comments are important to consider. If she only uses materials based on student interest, she may very easily allow students to use materials that are "fun" to handle, but do little to promote meaningful science learning. Further, her decision to use student interest only rather than research based ideas, such as developmental learning theory, reflects a possible disregard for
learning theory. However, in the interaction above, the first follow-up question (What else would you consider?) that the interviewer asks is broadly stated like an initiatory question. The student is not able to manage the cognitive demand in this question and responds by claiming that she has little more to add.

Intriguingly, the next move the interviewer makes is to ask a second follow-up question as shown below:

I: Let’s suppose that you’re a kindergarten teacher and you have a science corner where you have, beyond just your regular science instruction, you’ve got this spot in the corner where kids can bring in stuff and use little hand lens and look at bugs or whatever. So let’s say they’ve been bringing in ladybugs and flies and all kinds of things and looking at them and having a great time with it. And now let’s say the Intel Company has decided that they will donate these nice high powered microscopes for your class. And you put the fly under there and you see an eyeball—this big compound eye. You can project this image onto a big screen because these are computer based microscopes. You can plug them into a computer. Um, how might you think through whether you want to use that in your class or not?

S: I think it goes back to the students and the equipment in a way because, like for kindergartners, they’re having a good enough time looking at it with a hand lens and focusing in on specific parts of the bug. I think it’s going to be over their head at that point. (Reference: P1 S3 I22, Paragraph 73)

Notably, the student’s response in this case indicates that she is now thinking about whether the students will be able to process the content associated with using the microscope; although, she still seems concerned about student interest in that she makes mention that the students will be having “a good enough time” whether the kindergartners use hand lenses or a microscope. To an extent, the student’s response here is more credible than before. This line of questioning continues as follows:
S: ...I think it’s going to be over their head at that point.
I: Why might that be?
S: Because of their stage of development.
I: Why is that?
S: I knew you were going to say that. I’m not sure.
I: Kids are just seeing a big compound eye. How might that be beyond what they can fully comprehend?
S: I think it would be a [student’s voice lowers]
I: How so?
S: They didn’t--like if they put it under the microscope and they see this big eye, a kindergartner might think that the eye is a really big part on the bug or something. You know, they might not understand that technology and be ready to use it where if they use a lens they can work at it and it will be more proportioned.
I: And I think one of the things we need to be concerned about is that if they see something like a compound eye that looks like a big soccer ball and they can’t see the detail with just looking at the insect, how are they going to know that’s actually an eye ball?
S: Um, because it doesn’t look anything like the original object; it doesn’t look like just a big version of the original object. They won’t make that leap that there actually is part of the insect. It’s now something new to them. Preoperational kids can’t make that transfer very well and so the chances of them understanding even what they are looking at is just about zero in that case.
I: Um, so considering this, let’s go back to the original question. What kinds of things would you need to think about when deciding on the materials for your classroom?
S: They’re development--what level they’re at.
I: What else?
S: Any misconceptions they might have with the equipment and the materials.
I: What else?
S: I think what they need...I don’t think in science class you always need to have this microscope and the best of everything. It can be just regular things that you have around.
I: And in what ways would common materials actually be better than having all the expensive science equipment?
S: I think that it’s good for kids to know that science isn’t just technology and all that stuff....You don’t need to have any particular equipment to do science.

I: And how is the use of common everyday materials consistent with what we know about how kids learn?

S: They have experience with it. They’ve had prior experiences and prior knowledge about almost everything that they run into.

I: So how might that influence their learning?

S: We can start with what they already know and then they can make sense of what they are learning in the class. By them doing an experiment with it, they can understand more about the experiment in regard to what it is. (Reference: P1 S3 I22, Paragraph 74)

In this line of questioning Joanne asks follow-up questions that are opportunistic and directed toward consideration of learning theory. The use of a critical incident appears to be helpful for this student to make connections more clearly and more thoroughly than when Joanne first asked, “What else would you consider?”

The interviewers’ use of probing questions involving critical incidents is shown in Figure 29. Joanne and Crystal tended to ask very few questions involving critical incidents in Semesters 1 and 2. Andrea asked a number of questions in Semester 1 and then dropped to a similar number as Crystal and Joanne from Semester 2 onward. Semesters 3-5 appear to be times of growth in use of critical incidents in probing questions as higher frequencies are present accordingly. This code is considered to be a highly sophisticated move by the interviewer because more evidence of student learning tended to be evident.
In this study, initiatory questions in oral defenses principally fostered getting students to share their ideas and served important diagnostic purposes while questions involving critical incidents principally fostered situations where student learning was evident. Use of initiatory questions in combination with critical incident questions resonates with the two-fold purpose of conducting oral defenses and is consistent with practices that were advocated in the methods courses under study.

Use of explanation also provides evidence to support how the participants promoted student thinking. Instruction that is consistent with conceptual change
research involves first designing situations where students have opportunity to recognize insufficiencies in their current ideas. After students are dissatisfied with their current ideas, then students are more receptive to listening to an explanation relating to a new, intelligible idea. The code regarding explanation that most closely aligns with conceptual change research is explanation coupled with scaffolding (ATLAS.ti Code: E3A). The code that most ignores conceptual change research is when the teacher explains with few probing questions (ATLAS.ti Code: E1A). The participants’ implementation of these types of explanation are shown in Figures 30 and 31:

Figure 30. Frequencies of explanation with little probing—All participants
Figure 30 indicates that the interviewers seldom explain ideas without much probing. In Figure 31, the participants increasingly used explanation coupled with scaffolding over time. Both limiting the use of explanation without probing students' thinking as well increasingly using lines of questioning coupled with explanation support the participants' claim that they intended to use explanation with discretion to promote student thinking and create situations where meaningful learning is more likely to occur.
Finding 2: Evidence exists to support that the participants assisted students to see errors in their thinking.

General observations of the participants in oral defenses provide evidence of how their practice assisted students in seeing errors in their thinking. Specifically, notable aspects of Joanne's practice will be examined followed by Andrea's practice to show specific indicators related to this finding.

Joanne is adept at pointing out to students where they have contradictions or incomplete thinking on a topic. In other words, Joanne finds "holes" in students' thinking. When she notices that students have "holes" in their argument, she asks a confronting question as is evident in the following interview transcript:

<table>
<thead>
<tr>
<th>Researcher's Commentary</th>
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<tr>
<td>Interviewer asks about the teacher's role when conducting class discussions</td>
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I: When people were doing those presentations...in class, I thought students discussed things back and forth amongst themselves. What did I do to get that to happen?  
S: I remember you bringing up questions that may have been, oh, I would say the whole thing was useful to us because it was about the paper that we were writing ourselves. When you asked a couple of questions, I was thinking more in terms of is this something that I'm going to be needing in my paper or is this something to work off of from what she just asked?...  
I: How did I give my students the impression that they were expected to ask questions, rather than it just being me asking the questions and everybody else listening?  
S: You sat down--that I can remember--and not in front of the room right in front of the presenters, off to the side or in the back. You were listening, paying attention. You acted as though it was something you had to write and
Notice that the student describes things that she felt Joanne did to promote class discussion. However, Joanne notices that the student downplays the teacher's role so much that she describes behaviors that make it seem like the teacher need not be in the room with the students. Joanne *confronts* this notion by asking the student, “So how would it have been different if I had just left the room?”

The student seems at a loss for words and, thus, dissatisfied to an extent with her previous ideas.

you were interested in finding out what kind of information we found. How we could use it in our papers? When the presenters were done, you didn’t jump up and start asking questions. You just were there. They all asked, what questions do you have?

I: What are the things that I did to manipulate that environment to get people talking?
S: By you not talking or by you not taking over and not being in the center and making it our responsibility to find out what we needed.

I: *So how would that have been different if I had just left the room?*
S: I think having you there made it, um, made it, um, so it wasn’t just like when we were just doing, I’m trying to think, um, it’s really, um, I think the kinds of questions they asked were lower...It wasn’t, I mean you were there because it was important that we were all doing it not just because...[voice trails off] (Reference: PI S3 l29, Paragraph 19)

Andrea assists students in recognizing errors in their thinking by guiding them to create “thickets” of immature ideas. She is adept at getting students to create “snares” for themselves and make statements which, in the end, are contradictory. This line of questioning often ends with, “Before you said ____. Now you’re saying ____. How do you reconcile those two different ideas?” She gets information out of students which she then uses to confront them. Andrea’s ability to lure students to create “thickets of immature ideas” involves many codes working in combination. This practice is exemplified in the following interview excerpt:
Notice here that the student indicates she doesn't agree with learning theory.

The students indicates that she thinks “learning is different for everybody.” Andrea poses a new question here about how people learn language. This question is subtle and causes the student to shift her thinking to a different course. Then, very subtly, Andrea gets this student to argue against an idea she just conveyed using a seemingly unrelated topic, language development. In this question, Andrea draws from common past experiences that she and the student have had.

Notice here that the student now makes a claim I: Let’s go forward with something you said earlier. You said that the value of having multiple strategies is because all students learn differently. How do you reconcile that with learning theory which asserts that all students learn the same?
S: I don’t agree with that at all. Um, with my background in special education, which I hear is very different from, um, some of my methods classes in teaching science. Ah, I think that’s a load of... [laughs] I’m sorry. I know that I learn completely differently from my mom. My mom can sit through a lecture and she can just soak it up like a sponge. Um, if I sit through a lecture and if I’m not engaged, if I’m not talking, I’m not gonna learn a thing. If I’m writing down something, yah, I-I could write it down verbatim, but I’m not gonna know anything that happened. Um... Just...just... [pause] I just think that learning is different for everybody.
I: How do you, um, people learn language?
S: I think from... [long pause] I’m thinking back to some of my old classes, now. Um, through their parents, through listening, through the social engagement they get when they’re growing up-um, through their parents, you know, talking to them, responding to their babbles. Um, repetition, um...
I: So let’s say that we have this idea that someone isn’t going to learn as well through, let’s say, social interaction. Would we then say that they--you know, social interaction--that isn’t very important for them, so, we don’t need to read to them and we don’t need to talk to them, because, you know, they don’t learn that way. Is that something that we would want to do?
S: No.
I: Well, why?
S: No, that’s not what I was trying to say, I guess....No, I think all students need to be read to and
concerning how it would be "crazy" to say that people don't learn through social interaction (i.e., "who doesn't learn this way?") need to be talked to, and I think that it's crazy to say that just because a kid doesn't learn socially—\textit{who doesn't learn this way}—that they shouldn't have any kind of social interaction. I think that's just crazy.

I: So why is it so crucial that we read to kids?

S: Because they need that exposure. They need that—\textit{they need that}... It's just that important: Um, it helps—\textit{it helps them in their—in their words}, in building their vocabulary, and as they get older,... [cut off by Andrea here]

I: How does it help with building their vocabulary?

S: Because they—they hear you, and they listen to you, and especially if it's someone that they've been with for a long time, they can really, you know, become trusting and focused and... [sighs] Just that repetition.

I: Well, it seems like here you're saying that all students need that, and therefore, all students learn in that manner. So how do you reconcile that with the fact that you said earlier that all students learn differently?

S: Hmm. [long pause] I'm trying to decide if I should defend my answer or if I should change it. Um... [long pause] I'll defend it and then I'll change it. How's that sound? [laughs]

I: What's your rationale for doing both?

S: Ah, because I think that there are circumstances that—\textit{that—there—there are very specific circumstances} that I guess, um, can be taken into consideration, so part of me says, like, \textit{I have to defend my answer because I gave it, but then part of me wants to change it because I see your point}. (Reference: P2 S3 116, Paragraph 33)

After reflecting on Joanne and Andrea's strengths, I recognize that as an interviewer myself, I shy away from confronting students' ideas and working to create "thickets" out of their ideas. An examination of the sheer number of times I
coded myself making these sorts of decisions is lower than I would like to observe. I believe that I could improve my practice by attending to these areas of weakness.

The following excerpt from a research memo that was written after coding Joanne’s and Andrea’s data contains advice that pertains to assisting a less experienced interviewer in learning to conduct oral defenses using practices exemplified by Joanne and Andrea:

When guiding a person who is learning to diagnose and teach in oral defenses, I think that there are two plateaus of development. The first plateau occurs when an interviewer focuses completely on what to do next: Do I ask a question? Do I explain? What do I do next? The second plateau occurs when the interviewer starts to think about how they could bring students to recognize the flaws in their thinking. At this second plateau, critical questions for the interviewer to consider are: What inconsistencies could I get the students to bring forward (i.e., Andrea—creating a “thicket”)? What is inconsistent, illogical and unsupported in what the student has conveyed? How might one assist the student to see the “holes” in their logic? (i.e., Joanne—looking for “holes”)? How might students exit a line of questioning too soon without reaching dissatisfaction? (Reference: I2 S2 Summary, 5/09/05)

I believe the advice I listed above would be helpful to me (and other less experienced interviewers) as one strives to improve.

Finding 3: Evidence exists to suggest that the participants’ practices reflected careful implementation of the teacher’s role.

Carefully implementing the teacher’s role as defined in this study involves attending to many aspects of one’s practice. Specific strategies pertinent in the context of conducting an oral defense include deliberately phrasing questions,
listening carefully to students’ responses, and shaping questions that are based on the students’ previous responses. All these practices combined are exemplified in the following interview excerpt:

Researcher’s Commentary

I: So let’s suppose that you’re put on your district’s curriculum committee. And they’re trying to make the decision about whether they should get rid of the textbooks and adopt sort of a hands on based program that has, you know, kits that are filled with stuff to use, rather than the textbook based program. Which would you push for and why?

S: I would push more for get rid of the text and like the hands on things because I’ve actually seen this happen. Um, I don’t know if the students are going to understand it, but I like....Can I start over?

I: Sure.

S: Okay,...I’ve had the same second grade teacher the last three years and they always have this math textbook. And this last year they got rid of that and got, you know, a new curriculum, and it’s more hands on. Like you said, it’s more work, but having been there for the year, I could tell the students are dong a lot better....Kids are going to understand it better....

I: So what evidence would you be able to provide to a district to support why they would learn better using something hands on?

S: From my classroom?

I: From your knowledge base. Think about what you know about how people learn. Why would hands on work better?

S: Because they’re getting to develop their own knowledge of the subject. They’re not doing their reading yet or, you know, being told, well, you know, 2 plus 2 is 4 because you know I said so, or the book said so. They’re figuring it

Notice that the student’s ideas about learning theory are potentially filled with misconceptions.
Joanne confronts the statement that the student made about “kids needing to build their own knowledge.” The student evade the confronting question.

Joanne directs the student to specifically consider developmental learning theory.

Joanne conveys to the student that she is going to now use a string of related questions presumably for the purpose of promoting student learning. A number of linked questions follow.

out for themselves... And the more you work with things and try to figure it out yourself on your own methods of figuring it out, it’s going to stick with them for a lot longer.

I: So, what if somebody comes back and says, yah, but kids are always building their own knowledge. Even in a lecture or reading a textbook, they still have to take that information and try to piece it together.

S: Well, from my own experience last month, you know, I sat in lecture and I took notes. And I wasn’t really getting it... if you don’t have any experience or aren’t able to apply something to anything, you’re not going to understand it as well....

I: So let’s go to what you know about developmental learning theory. How might you use developmental learning theory to help support why hands on is going to help kids learn better?

S: Well, their development for one. [The students] belong to stages. They’re each going to go, you know, to each stage in order, but at different times and there’s a stage with hands on material.

I: I’m going to break this down into a string of [short answer questions.] What stage are elementary kids primarily going to be in?

S: Like sensorimotor?

I: Ah-huh, consider K through 6

S: Operational

I: So after they transition out of pre-operational, about age six or seven somewhere in there, you’re going to deal with kids who are now concrete operational. The chances are likely you’re going to be facing one of those, you know, two types of thinking. What do we know about what those kids need in order to understand things?

S: From their experiences

I: And what do we know they have trouble with?

S: Things they don’t, things they aren’t, seeing things that aren’t right there for them to see right in front of them.

I: So if you give a kid a textbook that talks about science
Joanne shifts the questioning to consider how constructivist learning theory is helpful in this instance.

Here is evidence that the student associates experience with prior knowledge development. Joanne then comments that she and the student reached concepts, what are they going to have problems with?

S: They’re going to have problems understanding it because they’re not seeing it. They’re not seeing how it works, you know, how it works, how to do things before figuring this out. They’re just going to see it in a book. It’s a bunch of words and they’re not going to get those hands on experiences.

I: And they might be able to picture some of those things, you know, that they’re reading, but it’s going to be much more difficult. And so what we know about developmental learning theory is that kids are going to need concrete experiences before we engage them into abstract thinking about it, like text. Text is very abstract. You have to--you know, read lines on a piece of paper and somehow connect that with a concept out there. That’s a very abstract thing that we ask even very young children to do. And we can see that kids have problems reading typically until they reach the concrete operational stage. Once they transition over that hurdle at age six or seven, you see literacy just flourish....It’s enough to have them read about things that are familiar. It’s very difficult to read about things that are unfamiliar, so it adds a level of abstraction there. Now let’s hit this from a constructivist learning theory standpoint. What do you know about constructivist learning theory that’s going to advocate that you should have a hands on science program?

S: With constructivism, they are building their own knowledge. They are using materials to figure things out. The teacher is there, I mean like, kind of guiding them. Giving them like a base to start, but they’re building it on their own. And they’re figuring things out on their own instead of being told or reading, you know, this is why.

I: Now, what do they build their knowledge based on?

S: Prior experiences, what they already know.

I: So what do we have to give them in order to help them build understandings?

S: Experience.

I: Which, again, gets back to hands on science. Through a
Joanne didn’t construct lines of questions consistently as exemplified above until later semesters. As she did so, she more consistently portrayed the teacher’s role to her students in ways that were consistent with advocated practices in the methods courses under study. Additionally, this dialogue displays why teaching methods is so uniquely challenging. As Joanne was working with this student, she was working on two planes--teaching the student content (learning theory) while at the same time teaching, or at least modeling, the pedagogy associated with questioning. Joanne conveyed her decision-making explicitly to the student by attending her to how questioning had just been used to promote learning for this particular student.

Finding 4: All three participants show room to improve.

While the participants are making many decisions that align with practices advocated in the methods courses that they teach, science teacher educators who desire to be and remain exemplary in their teaching continually must assess their practice and design strategies for improvement. After having closely observed the practices of the three participants, recommendations for individual and collective improvement are put forward.
For Joanne, I recommend changing how she uses explanation. In the interviews I observed, Joanne frequently explained ideas after she demonstrated proficiency getting students to make new connections through a series of scaffolding questions. These explanations took significant portions of time in the interviews. When time is invested greatly in explanation, less time is available to evaluate whether the student learned anything from the explanation. Thus, in Joanne’s interviews, there is a lack of evidence to support that the student accurately incorporated what was explained into his or her understanding. In subsequent interviews, I recommend concentrating on when to use explanation, how long one chooses to explain and what evidence exists to validate that the student strongly incorporated ideas from the explanation into his or her thinking.

For Andrea, I noticed that when she chose to interrogate students’ understanding of learning theory, she focused mostly on constructivist learning theory and developmental learning theory; some on social learning theory and very little on behavioral learning theory despite the emphasis on all four learning theories in the course itself. Inconsistency is conveyed when content in a course is emphasized in class throughout the semester, but then not mentioned in evaluative situations. I challenge Andrea to incorporate discussion of all four learning theories into her teaching.
With regard to my own practice, I am going to seek ways to confront students' errant and insufficient ideas. Additionally, I need to be bold about explaining my thinking. I can work on these weaknesses by doing the following:

(1) I need to stay immersed in literature on effective teaching. (2) I need to engage in conversations with colleagues who are more experienced than me and probe how they rationalize their decisions in practice. (3) I need to engage in conversations with colleagues who seek to improve their teaching. As I listen, I need to intentionally examine their ideas for inconsistencies. Additionally, I need prepare to answer questions like, “What would you do if....? Why would you choose to do that? Wouldn’t it be better to...?” These questions would challenge me to articulate what I do in practice and why. (4) I need to present at reputable conferences on science teacher education where I would be challenged to expertly explain myself. (5) I need to impress the following question into my thinking as I teach: What is lost when I bypass moments when students are ready to process new information, or worse yet, don’t even recognize inconsistencies in their thinking?

Overall, all three participants struggled with responding to students. For example, Joanne explains too much too soon. To change this situation would require mentally projecting out a line of argument and then constructing a series of questions that assists the student is making smaller connections within this larger
scheme. Early oral defenses show failed attempts in this area as Joanne and the other participants questioned poorly and the students adeptly evaded the questions. Similarly, while recognizing the need to respond, I shy away from confronting students' ideas. The possible emotional stress on the student may account for hesitancy on my part. We must recognize that there is considerable risk-taking involved when a student presents his or her ideas openly before an interviewer. Consider that no matter how professional and reputable a doctor, a patient is acutely aware of the embarrassment associated with undressing for an examination. Analogously, when teachers teach as Shulman (2000) writes by "putting the inside out, working on it together while it is out, then putting the outside back in" (p. 133), this is "nudity" in a cognitive sense.

When eliciting students' ideas, a teacher must monitor closely how a student is responding emotionally and then bear down or back away selectively based on decisions concerning what the student can and can't handle. A wrong move could mean that a student's dignity is at risk in front of an interviewer, or worse, in front of one's peers in a classroom setting. Interviewers must be keenly aware of a number of factors. They must sense people's emotional condition and alter their decisions accordingly. They must have extreme skill in projecting where the student should be and connect that level of understanding to where the student is to start.
With an accurate projection, they must structure multiple questions and/or statements that will, given a particular student's current thinking, be productive in moving a student forward in his or her learning. All of these complexities are even more profound when considering the myriad misconceptions that students hold about teaching and learning. Responding to students requires sensitivity, logic, deftness in constructing questions, and sometimes humor. Hardly a situation presents itself in teaching that is more complex than responding effectively to students.

**Summary of Results: Research Question 2**

Based on interpretations of evidence, the participants did not start effective in their practices and they regressed before getting better to the point where they practiced what they preach. The participants did use teaching practices that consistently promote student thinking. At times, they assisted students to recognize errors in their thinking and exemplified the teacher's role in ways that are consistent with advocated practices. Additionally, all participants still have room to improve, particularly in how they respond to students.
CHAPTER V: GENERAL DISCUSSION

One might argue that teacher educators are at least once removed from "real" classrooms (i.e., classrooms in schools for grades K-12), and, thus, other studies involving participants who are directly in contact with students in K-12 settings warrant more attention to the exclusion of this one. While studies involving teachers in K-12 settings are certainly needed in an effort to research the effectiveness of teacher education programs, I would argue that the practices of science teacher educators are critical to study in order to make clear, research-supported recommendations to improve science teacher education and teacher education in general. This study is important because it focuses on the practices of science teacher educators as they work on two planes—modeling pedagogy while simultaneously teaching the content they are modeling. No other discipline faces such a unique challenge.

This study examined the practices of science teacher educators in one specific aspect of a science methods course they were teaching, an oral defense. The oral defense is a microcosm of the challenges a science teacher educator encounters in practice. In an oral defense setting, a science teacher educator works individually with a student and has the challenge of diagnosing student thinking and promoting learning given pressing time constraints and potential emotional stress for the
student. Findings from this study are insightful for science teacher educators who seek to better understand and more effectively conduct oral defenses. However, to limit the impact of this study to situations only involving oral defenses with preservice teachers in elementary science methods is near-sighted. Importantly, if a science teacher educator is unable to create meaningful learning opportunities with a single student in an oral defense setting, the likelihood that one is able to do so in a more complex setting, such as a large group in a classroom setting, is low. When science teacher educators cannot effectively model the content they are trying to teach, methods students perceive a gap between what the "expert" advocates and what can be done in real settings.

Professor in the truest sense of the word is one who professes— one who declares. Professors are experts in a field of study by the very nature of their position. The discipline of professors of education is pedagogy. If teacher educators profess expertise in pedagogy and can not exemplify practices consistent with what they profess, then they deserve to be ignored. This would be asking a novice to do what the "expert" cannot. This message of "do as I say, not as I do" contributes to worsening the ongoing problem of preservice teachers’ rejection of content associated with their teacher education coursework and leaves them little recourse
but to teach as they remember being taught (Kagan, 1992; Lortie, 1975; Skamp & Mueller, 2001; Windschitl, 2005).

Implications

If this study is corroborated by other studies beyond this sample, then major implications exist. Overall, this study accentuates the complexities involved in teaching science methods and the naïveté, if not irresponsibility, of assuming that if one has taught science, then one can teach science methods. All three participants in this study were experienced in teaching science, hard-working, reflective, and well-intentioned. However, all three were incompetent as far as the pedagogy that they modeled initially, with the most experienced teacher of the three beginning at the lowest level. Obviously it would be ludicrous to ask a graduate student in geology to be in charge of instruction in a senior-level geology course. One isn’t considered “expert” yet, and, thus, better serves the geology department as a learner and apprentice research assistant rather than instructor of a course.

However, in teacher education, such ludicrousness occurs. Respected former science teachers are assumed to be competent methods instructors. Temporary instructors and/or graduate students are hired to fill vacancies in teaching positions for methods classes days before a semester of instruction begins. Graduate students agree to teach, but only until a “real opportunity” arises perpetuating the notion
asserted by Windschitl (2005) that teaching is really just a "temporary gig" en route
to more prestigious, lucrative endeavors. To teach methods effectively, considerable
time must be spent conducting classroom observations, reflecting on one's
observations, reading literature, and developing as much PCK related to teaching
methods as one can before attempting to teach methods content. This reflection is
not possible in a one to two day span prior to the beginning of a semester. Careful
measures must be taken to facilitate the development of science teacher educators in
an effort to make one an "expert" in teaching pedagogy as fast as possible. Based on
this study, a series of recommendations are important to consider.

**Tools to Evaluate One's Practice Systematically**

Systematic self-analysis is critical to promote improvement in practice. A tool
to facilitate systematic evaluation of one's practices as a science teacher educator
teaching a methods course is the coding scheme that was developed in this study.
Faculty could use the coding scheme as a continuum of expertise to ascertain their
practice and identify associated patterns. In this process, attention would be drawn
to the sophistication of one's decision-making. After situating one's practices along a
continuum of expertise, one could then use descriptions of more sophisticated
decision-making to foster reflection and design strategies for systematic
improvement accordingly.
A resource that could assist science teacher educators as they seek to improve is a compilation of questions involving critical incidents. In this study, initiatory questions principally served to aid the interviewers in diagnosing student thinking. After careful diagnosis, responding questions asked by the interviewers principally facilitated student learning, but were difficult to generate. Responding questions that were particularly useful in this study were questions involving critical incidents. Literature published to date on conducting oral defenses clearly describes broad, initiatory questions that are useful, but does not include descriptions of questions or responses that involve critical incidents. Reading such literature would provide less experienced interviewers with a resource to assist them when they are struggling (as all the participants did) to know how to respond to common misconceptions that students hold.

**Mentorship and Support**

Based on findings in this study, mentorship is critical, but not mentorship too far removed from one's level of expertise as a science teacher educator. Joanne's mentor was too expert and she struggled more than Crystal and Andrea. In the absence of a mentor who is close in skill level, perhaps the coding guide could be used to create a scaffold for novices as they work with a more expert mentor. Time
would be well spent with a mentor in a preparatory period before beginning to teach and throughout one’s first three semesters of teaching.

In addition to early and ongoing mentorship, support systems need to be in place within institutions to foster teacher educator development. In this study, promotion and tenure demands were associated with stagnation and possible regression in teaching effectiveness. The expectation that faculty will be excellent in everything, or worse, excellent in research only, may ensure that teacher education remains disrespected and ineffective.

**Knowledge of Expected Patterns of Growth as a Science Teacher Educator**

Less experienced science teacher educators (and administrators who evaluate the practices of science teacher educators) should expect periods of growth to be accompanied by spurts of regression as one seeks to become more effective. Based on findings from this study, one cannot expect instant expertise in teaching science methods content even if one is well-intentioned, reflective, hard-working, and experienced as a teacher of science. Times of regression are most likely when one is experimenting greatly with one’s practice, and periods of growth over the course of semesters are more likely after at least three semesters of experience teaching methods.
Advice about Avoiding Periods of Regression

Familiarizing oneself with preservice teachers’ ideas about teaching and learning is of utmost importance right from the start. A characteristic of experts is that they perceive patterns and free their working memory for other tasks (Gagne, Yekovich, & Yekovich, 1993). One should classify students’ ideas into patterns and/or possible misconceptions to facilitate the process of more efficiently diagnosing errors in students’ thinking. However, pattern recognition alone is necessary, but insufficient. After recognizing a particular pattern, one must project possible implications of the students’ views. These projections are prerequisite to designing questions that will assist students in recognizing errors in their thinking.

To illustrate this process, consider the following example framed around a common student misconception about learning theory, learning styles and lesson plan models:

I: What is the value of having multiple strategies to promote a goal like critical thinking?
S: Teachers must be able to teach using multiple strategies because each child learns differently. Some children need direct instruction whereas others need a hands-on approach--what the teacher needs to do is figure out what is best for each child.

If one extends this student’s idea to a possible logical conclusion, this student could now justify structuring lessons using only one style of instruction (e.g., direct instruction) depending on what he or she decides is best for a particular group of
children or having lessons so diverse, children miss the point of instruction and the teacher quickly becomes exhausted. To assist the student in recognizing this possible implication, the science teacher educator might select to ask questions like the following:

- What do we know about concrete thinkers? (Possible answer: They are typically ages eight-eleven, but not necessarily.)
- What information can concrete thinkers understand? (Possible answer: They can only conceptualize things that they can physically handle.)
- What is hard for a concrete thinker to understand? (Possible answer: They have difficulty with concepts that are abstract.)
- What can teachers provide concrete thinkers to help them better understand ideas? (Possible answer: They can conceptualize what they have had experience handling, so giving them materials to manipulate to test their ideas is helpful.)
- What will be the developmental level of most elementary students? (Possible answer: Concrete operational)
- Let's say that you're teaching a second grade class. How would using hands-on instruction be important? (Possible answer: Hands-on instruction would give the students an opportunity to test their ideas using materials that they can manipulate.)
- How would it be different if you gave them a textbook to read first before you gave them opportunity to work with materials? (Possible answer: The students wouldn't understand what they were reading if they didn't have any experiences with what the words meant.)

Now the science teacher educator is poised to ask a confronting question:

- Before you said that some students learn better by hands-on instruction and some learn better by direct instruction, etc. Now, you just mentioned that all of your second grade class would benefit from hands-on instruction. How do you reconcile those two different views?
A confronting question patterned like the one above is difficult for students to evade because they are directed to consider contradictory views conveyed in their own words.

**Further Study**

This study is exploratory in nature and raises several issues for further study, particularly with regard to professional growth in science teacher educators. Possible studies include:

1. To what extent can the coding scheme developed in this study promote improvement in the practices modeled by science teacher educators?

2. What are the effects of mentorship at various times on the practices of less experienced science teacher educators? Possible times to consider are preparatory periods and during early periods in one's experience.

3. What strategies can elevate one's level of expertise from the start?

4. How can periods of regression be avoided?

5. What differences exist in the practices of former methods students before and after identified improvements in the practices modeled by science teacher educators in oral defenses and in methods classes?

6. Windschitl (2005) claims that research on science teacher education has insufficiently studied the effectiveness of traditional and alternative forms of
teacher education on student learning. This claim raises the question: How might improvements in the practices of science teacher educators in traditional and alternative teacher education programs ultimately impact student learning of science content (grades K-12)? This question is admittedly complex to answer. However, an answer to this question would provide policymakers with empirical evidence that would assist in better defining "what it means for students to learn, 'what counts' as good teaching, and how aspiring educators become professionals" (Windschitl, 2005, p. 533).

(7) What knowledge bases are required for teaching methods coursework?

Teaching science to children (grades K-12) requires knowledge of science content (e.g., physical science), general pedagogy (e.g., questioning strategies, lesson plan models) and PCK for science content taught to children at various grade levels among others (Shulman, 1986). Methods instructors, however, must understand each of these knowledge bases in addition to PCK and content knowledge specifically for teaching methods. Further, the knowledge that one has must be explicit (not tacit) in order to effectively model and then teach the skills one is modeling.

Although vast amounts of literature are published on teachers' knowledge development, Munby et al. (2001) assert that we, in teacher education, still proceed
as if it were simple: "'We tell our students and they go out and teach,' seems to sum it up aptly" (p. 900). But while research on teachers' knowledge development has occurred, implications of such research have not been heeded by science teacher educators as they teach methods coursework. In other words, teaching in methods courses has simply not kept pace with research on how to teach effectively. When we fail to practice what we advocate, we present our students with a "professor" who seemingly doesn't know their content. Undoubtedly, students notice these failures which depletes the respect one has for us, as teacher educators, and for the discipline that we represent.

Conclusion

Throughout this study, I have used the phrase "science teacher educator" to refer to persons within schools of education who teach science methods courses. Admittedly, this study sampled only the practices of science teacher educators and findings must be interpreted with this in mind. However, I contend that all discussions in this study are pertinent to science teacher educators and teacher educators alike—no matter what the connection to a discipline, such as science, math or reading. Teacher educators must consider how to more closely align their practices with what they advocate in the courses they instruct and they must be passionately dedicated to invest time and energy into continuous improvement. The
rule, "do as I say, not as I do," ought not to be the message conveyed by teacher educators to anyone, let alone preservice teachers--those persons specifically who will be responsible to teach our nation's children (including two of my own).
REFERENCES CITED


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