Transitioning from Student Teacher to Teaching Professional:

Evolving Perspectives of Beginning Science Teachers

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Abstract

The transition from preservice science teacher education programs to the first years of full-time teaching is arguably one of the most critical stages in the professional development of science teachers. This report documents a longitudinal study aimed at enhancing the research base for understanding this critical stage. The research is framed as a comparative analysis of six cases of beginning science teachers. Data were collected over a two-year period spanning the participants' final year in a preservice education program and their first year as professional educators. In addition to the six case studies, partial data sets from an additional eight beginning science teachers are examined to address questions related to the retention of beginning science teachers. The breadth of cases studied extend findings of previous research on science teacher education relative to: 1) Gaps between beliefs about learning and actualized teaching practices, 2) Beginning teachers' perspectives on their preservice training programs, 3) Retention of early career science teachers, and 4) The significance of mentorship for beginning teachers. Dramatic differences in experiences among teachers, with varying levels of mentorship, were particularly striking and showcased considerable interactions between the beginning teacher's and his/her school community's commitments to professional development.

Keywords: Case study, Induction, Mentorship, Preservice teacher education

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Introduction

The induction phase represents a crucial period in the professional development of science teachers. It is commonly assumed that these early years are among the most challenging and professionally significant periods (Bianchini, Johnston, & Cavazos, 2003; Luft, 2007). Lasting pedagogical habits are established and critical decisions concerning long-term engagement in the profession are often made during this time. Unfortunately, beginning teachers, beginning science teachers in particular, all too often decide to leave the profession within their first few years of teaching leading to critical shortages of science teachers across the nation (Ingersol, 2003; NCEI, 2005).

This paper is the second report of a longitudinal study aimed at enhancing the research base for understanding early phases of science teacher professional development. In this report, we explore the perspectives teachers hold through their teaching practica and first year of full time teaching. We investigate their changing perspectives on science teaching and explore how they are succeeding, issues which challenge them, and what they have come to learn about teaching. We conducted this work through the creation of individual case studies derived from multiple data sources collected during the participants' final year in a teacher preparation program and their first year as professional teachers.

Our work adds to a growing body of literature, which uses case studies to inform science teacher education and professional development. While the case studies from a single research project are not generalizable to an entire population of preservice and beginning science teachers, they do provide valuable windows into the experiences of some individuals (Stake, 2005), which

can enhance our understandings of how to support and encourage retention and development of beginning teachers. Combined, a growing set of case study research projects can potentially provide a robust, empirically-rich foundation from which research-based decisions can be made. The aim of this project is to contribute to the body of case studies in science education, which can inform the field's continual efforts to improve science teacher education and professional development. In the sections that follow, we review several relatively recent case studies of preservice science teachers, beginning science teachers, and teachers transitioning between these two phases. We offer this review as a means of situating our own work, which is presented following the review of literature.

Case Studies of Science Teacher Development

In this section, we summarize case studies of early career science teachers that have been presented in the literature. We divide the research into three groups based on whether the focus of the studies are preservice teachers (i.e., students participating in teacher education programs), beginning teachers (i.e., teachers within the first few years of the career), or teachers transitioning between preservice and beginning teacher roles.

Preservice Teachers

Lemberger, Hewson, and Park (1999) conducted a comparative case study of three preservice science teachers using a combination of interviews and observations to determine how preservice teachers' conceptions of science developed over the course of their student teaching experience. Conceptions of science included the nature of science, science knowledge, science learning, science instruction, and the relationships between conceptions of science. The teachers were engaged in short-term teaching assignments (15-30 minutes) one or two times each week in a biology classroom for the duration of the semester. Interviews and observations were con-

ducted at the beginning of a semester to determine early conceptions of science and actual teaching actions, as well as at the end of the semester to determine late conceptions of science and actual teaching actions. Comparisons were then made between the two data sets followed by a discussion of how conceptions and actions changed in each teacher's case.

At the beginning of the semester, the researchers found that the teachers held a positivist view of knowledge, viewed biology as "static and fragmented," and felt that their responsibility as teachers was to ensure that students left their classrooms with "correct" ideas. By the end of the semester, the three preservice teachers still felt responsible for leaving students with the "correct" answer, but recognized the significance of students' alternative conceptions. The teachers still faced the challenge of knowing what to do with student alternative conceptions. Comparisons between their conceptions of biology and their conceptions of teaching science showed that the preservice teachers' positivist views of knowledge and transmissionist views of teaching were developed regardless of their conceptions of science.

Koballa, Glynn, and Upson (2005) looked at science teachers during the last year of an alternative certification program and developed three case studies based upon teachers that were characteristic of the other teachers in their program. Using interviews, classroom observations, and course artifacts, the three teachers were examined for their conceptions of science teaching and the comparison or contrast to their teaching practices. The teachers saw themselves as either facilitators of student learning, teachers of conceptual change, or facilitators of student understandings of science.

Koballa et al. found that "conceptions of teaching science held by the participants were resistant to change, even in the face of well-intentioned instruction" (p. 302). The participants' conceptions did not change over the course of the year-long program and did not necessarily

align with their teaching practices. For example, the teacher that saw herself as a "facilitator of the development of student understandings in science" used traditional, teacher-centered instruction that was bound by the curriculum. Classroom management had more of an impact on her instructional decisions than her espoused conception of science teaching. Koballa et al. suggest that preparation programs, especially alternative certification programs, should discuss how a teacher's conception of science teaching may influence teaching practices. Preparation programs should also discuss how working conceptions or contexts influence a teacher's ability to make their ideal science teaching conceptions a reality.

Given that teaching actions are not necessarily aligned with conceptions of science teaching, some case studies have looked at the ability of preservice teachers to engage in inquiry-based teaching. In order to determine the feasibility of preservice science teachers implementing inquiry during their student teaching experiences, Crawford (1999) conducted an in-depth case study of one preservice teacher's practice over the course of her last year of university coursework. The teacher was chosen because of her ability to design inquiry-based units with the idea that the purpose of study was to determine if preservice teachers could *implement* such units. Crawford examined two lesson plans that were developed and implemented. The teacher's formal written reflections and audio taped conversations with university supervisors were also examined to elicit the teacher's beliefs and practices regarding inquiry in the science classroom. Data collection occurred over a full calendar year and concluded during the first semester of the teacher's first year of full-time teaching.

Crawford found that the teacher's beliefs about inquiry were well-aligned with her teaching practices. The two lessons that were examined for inquiry content contained evidence of inquiry engagement and practices that aligned with the teacher's beliefs. The teacher attributed her

success to her prior research experiences, observations of project-oriented classrooms, collaborative and trusting relationships with her mentor teacher and other experts outside of the classroom, and ongoing reflection. She found teaching for clarity and facilitating group work difficult in the fall semester, while differentiating instruction, assessing prior student knowledge and skills, and communication with parents were the most challenging aspects of teaching during the spring semester. Despite these challenges, Crawford's case study showed that preservice teachers, under some circumstances, can implement inquiry-based science lessons. While this case study only examined one teacher's beliefs and practices, Crawford presented an encouraging picture of what some preservice teachers are capable.

Given the successes and challenges faced by the teacher in this particular study, Crawford suggests that preservice teacher programs should engage preservice teachers in authentic inquiry activities to provide them with practice in the inquiry process. Crawford also emphasizes the importance of placing preservice teachers in field experiences that model inquiry teaching. Exposure may be an equally important element to developing teachers who teach inquiry in the science classroom. Furthermore, Crawford suggests that preservice teachers should have scaffolded practice with planning scientific inquiry units, and should be given several opportunities to reflect on their own teaching.

A fourth case study of two preservice teachers further explored the influence of a teacher's personal history on their perceived roles as science teachers. Eick and Reed (2002) purposefully selected two preservice teachers because of their stark contrast in ability to use inquiry-based instruction in their student teaching experiences. Data sources included university transcripts, researcher reflections of observations, and interviews. As in Crawford's study, previous classroom experiences and interactions with teachers who modeled inquiry teaching influ-

enced the teaching practices of the preservice teachers. One teacher's personal learning needs, which included inquiry and constructivist models, informed her role identity as a teacher. The other teacher's inability to see herself as an inquiry-based teacher shaped her traditional teaching practices. Overall, Eick and Reed found that the past matters. Preservice teachers' role identities are strongly influenced by their past experiences as learners themselves. Their own learning needs and styles predicted their teaching styles.

Beginning Teachers

Researchers have also presented a number of case studies on beginning science teachers. Much of this work has focused on the differences between teachers' beliefs and practices, constraints to implementing inquiry instruction, and beginning teachers' role identities. Roehrig and Luft (2004) created case studies for fourteen participants in a teacher induction program. Data sources included interviews and classroom observations. The cases were divided into three groups based on the teachers' classroom practices: inquiry teachers, process-oriented teachers, and traditional teachers.

In general, inquiry teachers held student-centered beliefs and their teaching practices mirrored their own life experiences. Their perceptions of students' abilities and prior teacher training in inquiry instruction influenced their success with and challenges to inquiry teaching. The process-oriented teachers used activities and experiments that emphasized science process skills but rarely encouraged students to think about and discuss their conceptual understandings. The traditional teachers viewed science as "a body of knowledge that is verified through rigorous experimentation" (p.17). Three of the traditional teachers lacked strong science backgrounds, three lacked pedagogical backgrounds (they received alternative certificates or were uncertified), and

two others said that their context (student ability or administrative support) caused their lack of inquiry-based instruction.

Roehrig and Luft concluded that four factors are needed for successful inquiry-based instruction in science: 1) contemporary views of the nature of science, 2) student-centered beliefs, 3) content knowledge, and 4) appropriate instructional context. When beginning teachers perceived students as having "low ability" and when classroom management issues were present, implementation of inquiry instruction was restricted. Overall, regardless of preparation, all beginning teachers encountered difficulties implementing inquiry-based instruction.

Andersen, Evans, and Sorensen (2004) looked specifically at the relationship between self-efficacy in science teaching and teaching context. In this research, case studies were developed for three upper elementary science teachers using quantitative data from the STEBI-B and CBATS measurement tools. These instruments were administered at the beginning, middle, and end of a school year. Data were also collected through interviews and formal classroom observations. Favorable environments were characterized by the presence of mentoring partnerships, resources, materials, and favorable scheduling. Two teachers maintained average measures of self-efficacy in highly favorable environments. The third teacher's self-efficacy score decreased over the course of the year in the presence of an average environment. This suggests a link between high self-efficacies and favorable environments (i.e., mentoring, partnerships, resources, etc.). The quantitative approaches taken to develop the three case studies offered a long-term tracking ability to measure and compare the beliefs and practices of beginning teachers.

Volkmann and Anderson (1998) developed an in-depth case study of a high school chemistry teacher based on her personal journal. Specifically, the study looked at how the beginning teacher created her professional identity. Although the journal did not recount the teacher's expe-

riences as a preservice teacher, it did include information about how she struggled with making the transition to a beginning teacher. Unique to this study was its timing. No researcher was present at the time of the teacher's journal writing - it was analyzed six years after its creation – and was validated by a second first-year teacher's experiences.

In creation of a professional identity, the teacher wrestled with three major dilemmas: (1) feeling like a student versus the expectation to be an adult, (2) caring for students versus the need to command respect, and (3) disliking chemistry versus the expectation to be a chemistry expert. The solutions for each dilemma were not developed during the teacher's first year or on her own. It was only through collaboration with researchers and another beginning teacher six years later that those solutions were developed by creating a "professional identity" that agreed with her "personal identity." Volkmann and Anderson suggest that induction and mentoring partnerships need to focus on this discrepancy and help beginning teachers develop a professional identity that is not in conflict with, but aligns with their personal identity.

The Transition between Preservice and Beginning Teachers

Literature that focuses on the transition secondary science teachers make between preservice and beginning teacher is scarce. However, there are two reported case studies which look at this transition for secondary mathematics (Ensor, 2001) and elementary teachers (Levin & Ammon, 1992).

Ensor's (2001) study of seven secondary mathematics teachers in South Africa looked at how teachers recontextualize information learned during their university coursework to the secondary mathematics classroom. Drawing upon observations, interviews, and reflective teacher journals, Ensor found that preservice teachers drew more on their experiences with classroom teachers than what was learned in their university methods course. Teachers recontextualized

what they learned in their methods course during their first year of teaching, adapting ideas that emerged in their preservice programs to fit their particular teaching contexts. Ensor suggested that student teachers need to see more modeling of "best practices" so that they go beyond just using the way of talking about math that aligned with the terminology from their methods class and closer to the actual appropriate use of those practices.

In the longest case study research reviewed, Levin and Ammon (1992) conducted a five-year study, which spanned the preservice and beginning teacher experiences of four elementary educators to examine the development of their pedagogical thinking. Based on a model created by one of the authors, pedagogical thinking was broken into four strands: 1) behavior, 2) development, 3) learning, and 4) teaching. Previous studies showed that the complexity of pedagogical thinking increased with increased teaching experience.

Based on interviews and observations of the four teachers over five years (two as preservice teachers and three as beginning teachers), Levin and Ammon found that growth in thinking occurred in all four strands, although inconsistently among the strands. For example, at the end of their preservice years, the teachers seemed to show greatest growth in developmental thinking. The authors attributed this growth to a recent course the teachers took in child development. Similarly, the authors found the greatest growth in thinking about learning occurred during the teachers' three inservice years.

Based on observations of teacher practice, Levin and Ammon fournd that what a teacher actually did in the classroom was not always consistent with her reported thinking. A teacher who reported advanced thinking about teaching (meaning she was more aware of constructivist and student-centered teaching practices), in fact, demonstrated no ability to use advanced teaching practices. The authors concluded that growth in pedagogical thinking runs parallel to a

teacher's experience and extended student teaching experiences increases the likelihood for growth in thinking and for teaching practices to align with pedagogical thinking.

Levin and Ammon's study was unique in that it was a longitudinal case study of more than one teacher. The selection process for the teachers used in the case study, however, could lead to the selection of outliers in the population rather than teachers who are truly representative of other elementary teachers. All of the teachers in this study were chosen because they were considered the most successful in their preservice program, and taught three years in the same school and at the same grade level.

Summary of Findings

With the exception of the work presented by Koballa et al. (2005), the studies reviewed suggest that teachers' ideas about teaching and their own roles as educators evolve during teacher training programs (Lemberger, et al., 1999); the first years of professional teaching (Volkmann & Anderson, 1998); and over the transition between these two phases (Ensor, 2001). Common findings among the studies included early-career teachers struggling to adapt to the realities of authentic school contexts (Anderson, et al., 2004; Crawford, 1999; Koballa, et al., 2005; Roehrig & Luft, 2004; Volkman & Anderson, 1999) and the significance of teachers' prior experiences and dispositions (Crawford, 1999; Eick & Reed, 2002; Koballa, et al., 2005; Lemberger, et al., 1999; Roehrig & Luft, 2004). Many of the research reports also document inconsistencies between what early-career teachers say they espouse and what they actually do in the classroom (Koballa, et al., 2005; Lemberger, et al., 1999; Levin & Ammon, 1992; Roehrig & Luft, 2004). The disjunction between belief and practice is particularly pronounced in the context of inquiry-based pedagogies; however, at least two studies report some levels of success with early career teachers implementing inquiry (Crawford, 1999; Eick & Reed, 2002). The other im-

portant finding to emerge from this body of work is the significance of teaching context including mentorship and support as factors for the success of early career teachers (Anderson, et al., 2004; Ensor, 2001; Volkmann & Anderson, 1999).

Focus of the Study

The purpose of this study was to explore the development of beginning science teachers as they transition from preservice teacher education students to professional educators. We sought to better understand the evolving ideas of beginning teachers over a two year time period that spanned this transition. More specifically, we sought to answer the following research question:

- How do beginning science teachers' ideas about the practice of teaching and their own professional development evolve as they transition into the teaching profession?

We chose to investigate the question through the use of longitudinal case studies as a means of providing a rich data set through which inductively derived trends could emerge (Lincoln & Guba, 1985). The work is informed by a theoretical framework that draws from the results of previous case studies (reviewed above) as well as research on the influence preservice science teacher preparation programs (Beeth & Adadan, 2007), induction support for beginning science teachers (Plummer & Barrow, 1998; Simmons et al., 1999), and teacher induction (Huling-Austin, 1992) as well as reviews of teacher education (Davis, Petish & Smithey, 2006; Kagan, 1992; Wideen, Mayer-Smith & Moon, 1998).

Methods

Data Collection

For the case studies explored as a part of our work, we collected data over a span of two years as participants transitioned from university students to professional teachers. During year

one, participants completed a preservice science education training program (described below). During year two, participants were employed as science teachers in middle and high schools.

Year one data were supplied from three different sources: interviews, written reflections, and seminar field notes. Individual interviews were conducted in a private office after the student teaching experience. All of the interviews took place 1 to 3 months following the completion of student teaching. Each was audio-taped and transcribed for analysis. The interviews followed a semi-structured format: they proceeded in a conversational fashion but were guided by a set of questions. The interview protocol, which is provided in Sadler (2006), was designed to encourage participants to explain student teaching as they experienced it.

As a part of their university coursework, all participants wrote a series of reflections throughout the field experiences (prior to student teaching) and student teaching. At the conclusion of student teaching, participants completed a comprehensive "final reflection" designed to encourage students to reflect on and discuss the successes and problems they experienced throughout student teaching. The participants were asked to think about what they learned and how the experience affected their teaching. These written reflections were an additional source of data.

The third data source was field notes taken during student teaching seminars. During the ten weeks of student teaching, the entire cohort met one evening every other week to share experiences and insights. The first author facilitated these meetings which lasted for about two hours. Participation was required, but the meetings were informal in nature. A typical seminar began with a few announcements and a focus question or two, such as "how have you handled discipline issues?" or "what kinds of activities have you tried?" In every seminar, student discussion filled the rest of the meeting. The first author offered comments and suggestions when appropri-

ate and took extensive notes on the student-generated concerns and ideas. These notes served as the final year one data source.

Year two data were gathered from two sources: interviews and classroom observations. The first author conducted a second interview with participants at the end of their first year of full time teaching. These interviews followed a protocol very similar to year one interviews with minor modifications to account for obvious changes in the participants' roles. (The year two interview protocol is provided in Appendix A.) Most of these interviews were conducted in the schools at which the participants worked. Given the distances of the schools of two participants, two interviews were conducted over the phone. All interviews were audio-taped and fully transcribed.

For those participants working in schools close enough, the first author also made classroom observations and kept detailed field notes. For each participant, two or three classes were observed. The collected field notes focused on the general atmosphere of the classrooms, relationships between students and teachers, the nature of the classroom activities, and any other notable observations.

Sample

Data were collected from fourteen participants. Complete year one data sets (i.e., interviews, reflections, and field notes) were available for thirteen. Interviews were conducted with seven participants in year two and field observations were conducted with four of these interviewees. Sample mortality appears to be a significant concern given that only half of the participants participated in year two interviews. However, it should be noted that only ten individuals from the original sample were working as middle or high school teachers in year two. The three who were teaching but did not participate in the interviews were contacted, but they were not

available for interviews. Given data availability, case studies were prepared for six of the participants. These cases are presented below; data from the other eight participants were used for the two other Results sections ("Pragmatic Concerns" and "Where Are They Going?").

Data Analysis

Analysis proceeded in six stages. The first stage involved comprehensive analysis of year one data. This took place prior to year two data collection and the detailed results are presented in Sadler (2006). Stage one served as a backdrop for the remaining analytic steps. Stages two through five were conducted in a manner consistent with inductive analysis procedures (Lincoln & Guba, 1985) and the Constant Comparative Method (Strauss & Corbin, 1998). Interview transcripts served as the primary data sources for the analyses conducted. The remaining data (i.e., classroom observations, year one reflections, and seminar field notes) were positioned as secondary data sources used to challenge and corroborate emergent themes originally derived from the interview transcripts. In stage two, both authors independently examined the complete data sets for all participants who had completed year two interviews. The aims for this round of analysis were familiarization with the data sets, establishment of a strategy for comprehensive analysis, and identification of preliminary themes of interest. A result of stage two was the decision to frame study as a comparative case study with individual participants serving as the unit of analysis rather than an exclusive focus on themes cutting across individuals (as presented in the first report; Sadler, 2006).

In stage three, the authors independently summarized important themes for each participant. The authors then negotiated their findings until consensus was reached. These brief sketches formulated directly from the data served as outlines for the development of individual cases, which was the focus of stage four. Each author assumed primary responsibility for crafting

three of the six cases and identifying key data to support each contention. In stage five, both authors reviewed each case, compared assertions to original data sources, and made revisions. The need for a sixth stage emerged from the discussions which took place as a part of establishing the cases. Based on this work, the authors decided to search the available data for three specific themes not explicitly featured in the cases: 1) what helped prepare participants for success as teachers, 2) what recommendations they have for preparing science teachers, and 3) what their plans for the future entail. Participant ideas relative to the first two themes are based on the seven second year interviews. The final theme was examined for all fourteen participants. For individuals who did not complete year two interviews, email or phone contact was initiated to make this specific inquiry.

Program Description

The participants in this study were involved in a middle and secondary science teacher preparation program at a large Midwestern public university. Although these PST shared a common science methods course, which was associated with student teaching, and participated in a seminar designed to support the student teaching experience, they came to the program from a variety of backgrounds. Approximately half of the participants were undergraduate students seeking Bachelors degrees in science education. These students completed extensive coursework in at least two of the traditional science disciplines. The other half were Masters students who had already earned undergraduate degrees in a science content area; some were completing an M.A.T. (Master of Arts in Teaching) awarded by science content departments, and others were working toward an M.Ed. (Master of Education) with an emphasis in science education awarded by the School of Education. Regardless of the track, all participants had completed coursework in educational foundations, technology, psychology, multiculturalism, and content-area literacy.

In addition, they had completed an introductory methods course specific to middle and high school science instruction. This course was accompanied by a field experience during which students spent a minimum of 30 hours in a local middle or high school. During the student teaching semester, students participated in a six week intensive advanced methods course, completed a 40 hour field placement in the classroom in which they would ultimately student teach, and participated in a professional development seminar designed to support the student teaching experience. Student teaching officially commenced at the beginning of the semester's seventh week and extended for an additional ten weeks. The cohort also met for the student teaching seminars described earlier.

The participants of the current study completed the just-described student teaching semester in the fall of 2003. Most graduated at the semester's conclusion; one of the undergraduates graduated the following May. In the spring of 2004, a couple participants accepted temporary teaching assignments, many worked as substitute teachers, and a few were engaged in activities unrelated to teaching. Beginning in the fall of 2004, most participants were full-time science teachers in middle or high schools. Exceptions will be discussed later in the Results section.

Researcher Biases

The first author served as the instructor for the second methods course which was taught during the student teaching semester as well as the seminar facilitator. Prior to the student teaching semester, he had no personal interactions with any of the students involved, but having worked together everyday for six weeks, he and the students quickly developed relationships. By the time of the first round of data collection, the first author knew all the participants very well. Between the first and second rounds of data collection, interactions between the participants and the researcher were limited to a few emails and, in some cases, a couple phone calls. Given the

qualitative nature of the study, these relationships can be viewed as both strengths and weaknesses. The first author was personally engaged with all of the participants and was never positioned as an unbiased observer. These personal relationships certainly influenced the manner in which he interacted with the participants, and the relationships could have also affected some of the analyses. The interactions could have also influenced the responses participants offered during the interviews. On the other hand, these relationships afforded opportunities to which a less involved researcher would not have had access. The participants and researcher were on first name bases and were comfortable talking to one another. Although semi-structured interview formats were followed, the interviews were conversational in nature and flowed freely allowing participants to explore their own ideas with ease. Less familiar interview contexts can be adversely affected by anxiety and tension (Eisner, 1991). The emic perspective achieved certainly had the potential to affect the kinds of conclusions drawn as a part of this study, but it was this emic perspective that enabled the kind of in-depth data necessary for building the cases offered later in this manuscript. The second author had no interactions with the participants and came to "know" the novice teachers only through the data. Her contributions helped balance the interpretations of the more personally involved first author.

Results

This section is dominated by the presentation of the six cases. All of the cases are designed to provide some background information concerning who the teacher is and the nature of his/her teaching contexts. The cases obviously differ based on the experiences and ideas of individual participants, but the authors have chosen to focus on some common themes such as challenging issues, classroom successes, ideas about teaching, and teaching tendencies. All quotations presented are excerpted from interview transcripts. (Y1 represents the interview in year

one, and Y2 represents the interview in year two.) All names presented are pseudonyms used in the first report (Sadler, 2006).

Case 1: The average novice teacher—Ella

Ella was an average student and completed the undergraduate teacher preparation program with a specialization in biology. She taught both biology and chemistry in her student teaching assignment. Her teaching assignment was college preparatory classes structured so that all sections (across multiple teachers) attended a common lecture each week with opportunities for laboratory work and classroom activities in smaller groups (~30 students). In year two, Ella taught biology and earth systems to freshmen and sophomores in a large suburban high school that followed a block schedule. She felt comfortable asking colleagues for teaching suggestions and ideas, but she was not involved in any kind of formal mentorship program. In addition to her teaching assignment, she volunteered to serve as an assistant cheerleading coach.

Ella's challenges were similar in both years: discipline and time management. Discipline was her primary concern. In her student teaching assignment, she was initially reluctant to take any authoritative actions because she "felt like it was not [her] place" (Y1). In year two, she recognized it was her responsibility to manage the classroom, but continued to struggle with finding the line between being a friend and a teacher to the students.

> "I was too lenient and some kids would take advantage of me…now I'm more strict…I'm just trying to find that balance of where I can joke around with the kids and have fun with them and yet make them do their work and learn." (Y2)

While she identified her young age and youthful appearance as an advantageous quality in terms of relating to the students, she also recognized the tendency for students to not take her seriously.

Ella's second challenge, time management, assumed different forms across the two years. During student teaching, Ella expressed frustration with not having enough time to accomplish classroom teaching tasks. In her year two position, the time management challenge was due to

responsibilities outside of the classroom. She was overwhelmed by the amount of paperwork and other requirements that go beyond classroom teaching.

Despite these challenges, Ella found success in both years with relating to the students. She felt prepared to find alternative teaching strategies for ESL students, and reach those students that other teachers had difficulty reaching. She attributed some of this success to the adoption of alternative teaching methods and her intentions to provide authentic science experiences for her students. These strategies were consistent with her image of ideal science teaching. However, she readily admitted that her own practices fell short of the ideal. When asked to discuss the gap between her ideal and actual practice, Ella discussed student preparation and background knowledge as significant constraints. In both schools, she did not think that students were well prepared to engage in inquiry science:

> "When you first are with freshmen, or people who have never been in science, it is hard to jump in with hands on because they do not know exactly how to do it. It is not feasible to jump in hands on sometimes. You kind of have to start with explaining some information because they will not know how…" (Y1)
> "I do hands-on stuff a lot but its not to the extent that I would like…I don't know if the kids are gonna get this or if they have the background for that… They don't have the work ethic for it. They aren't devoted to looking into that and caring, so they won't read the lab and then they'll walk up to me and say, "what do I do?" And you know they won't really search for it, they won't push science so that gets kind of aggravating." (Y2)

Like many of her beginning teacher peers, Ella liked the idea of meaningfully engaging her students in the practice of science but found this goal difficult to actualize.

Case 1 Commentary

Ella presented herself as a competent, but average student in her preservice program. As an intern and a first-year teacher, she struggled with very typical beginning teacher issues: discipline, time management, and actualizing idealized visions of science teaching. Characteristic of a preservice teacher, Ella struggled with finding her discipline and teaching styles. Her supervising

teacher slowly turned over his class into her hands which left her unsure about her role as a disciplinarian. In her second year, she relied on informal relationships with peers to establish her own classroom rules and teaching style. Based on other reports of beginning teacher concerns and development, Ella is quite typical of the larger population of novice science teachers.

Case 2: The busy teacher—Feran

Feran earned a master's degree in science education with very strong undergraduate preparation in biology and chemistry. As a preservice teacher, Feran was a model student: she enthusiastically embraced reform-based pedagogies, critically reflected on her learning experiences, submitted exemplary work, and excelled in her practicum placements. During her student teaching experience, she worked with a cooperating teacher who took a very hands-off approach. He was happy to have Feran work in his classroom but did very little mentoring. As a student teacher, she taught biology in a modest-sized school situated in a rural community. The following year, a relatively small high school in a rural town hired her to teach chemistry, medical technology, and physical science. The medical technology course was an upper-level (junior and senior) science elective specifically designed for high performing students interested in medical careers. In addition to the heavy course load, Feran served as the freshman class faculty liaison and a sponsor for the school's peer mentoring program.

During year one, Feran's most significant challenges related to the specific context of her student teaching. She did not receive constructive feedback from her cooperating teacher or her university supervisor and felt the need for more critical evaluation of her work. Feran also felt constrained by a perceived lack of materials and equipment for enacting laboratory-based instruction. In year two, Feran continued to cite issues of context as challenges; she found it difficult to juggle preparation time for three different courses. However, her concerns seemed to be-

come more student-centered. She was very concerned with the extent to which her students were building (or not building) conceptual understanding.

> "I've been surprised by how often they have trouble with new information…I still think that inquiry-based learning is great, but there is so many times where I found that we do it and we get done and they still have no clue how to go about solving a problem…getting all the pieces to fall together has been more difficult than I would have envisioned." (Y2)

In terms of noting her achievements, Feran reported effective classroom management in both years. In year two, she also noted proficiency in the development of engaging, in-depth explorations particularly for the medical technology course. Because of its status as an elective and the advanced standing of the enrolled students, Feran felt more comfortable and ultimately proud of the innovative teaching approaches she brought to the class.

In discussing her typical teaching practices, Feran stressed presenting a variety of learning experiences. This was consistent with her comments after student teaching, but she was better able to support this contention with examples after the first full year. She discussed consistently interweaving hands-on experiments, small group work, lectures, independent research projects, and varied assessment strategies. This tendency was supported by the classroom observations during which Feran adeptly moved students from whole class instruction to group work and laboratory situations.

Case 2 Commentary

All teachers, who are doing their jobs, are busy, and most first year teachers are particularly overwhelmed by the commitments of their new jobs. But even among this group of notoriously hard-working individuals, Feran seemed busier than most. She taught three preps and coordinated two extra-curricular groups. Her classrooms also tended to be places full of activity. True to her teaching philosophy which demanded classroom variety, Feran's classes were characterized by many different activities and transitions. Finding a variety of activities for the stu-

dents to increase their involvement added to Feran's busy schedule. In year one, she committed herself to finding activities that would actively involve her students. By year two, she aimed to help students build deeper, conceptual understandings of the science covered in her classes. She wanted to create student-centered learning environments, but was somewhat constrained by time-consuming commitments.

Case 3: The content specialist who came to embrace relevance—Irvine

Irvine had come to the graduate teacher preparation program after having earned a bachelor's degree in biology with a minor in chemistry. He was a talented student who excelled academically and had successfully served as an undergraduate teaching assistant. From the very beginning of the program, it was easy to discern that Irvine was intelligent and knew a great deal about science, but it also became readily apparent that he was far more comfortable with traditional teaching strategies than reform-based, student-centered strategies. In the year one interview, he discussed the college model, wherein science was taught in lecture formats at a quick pace with periodic labs, as his ideal image of science teaching for college and high school learners.

As a student teacher, Irvine taught chemistry and AP biology under the tutelage of two cooperating teachers. He grew to really appreciate the mentorship of his chemistry mentor and viewed his experiences in this classroom as both educational and productive. Irvine's relationship with the biology teacher was very different; he disagreed with her approach to teaching, objected to the manner in which she provided guidance to him as a student teacher, and felt that she went out of her way to undermine his classroom authority. In year two, Irvine took a job teaching introductory biology and AP biology in an urban school with a diverse population. Unfortunately, he did not find the kind of administrators and colleagues he would have liked. He de-

scribed the relationship between the administration and faculty as completely non-supportive and even combative at times. This issue was worsened by a lack of faculty mentorship.

> "I am the senior biology teacher now at the school. We only had two to start with and the first guy got into a little bit of ethical trouble at the beginning of the year, so I wound up kind of carrying the department for the year. And our department head, who is supposedly my mentor, he seems like he was probably checked out two or three years ago…I'm getting zero mentoring." (Y2)

Beyond dealing with the perceived failure of those around him in leadership roles (one of his cooperating teachers in year one and both administrators and colleagues in year two), Irvine's most significant challenge in both years was dealing with the varying abilities of his students.

> "You come in and you've got the kid off the farm and the doctors' kids and the girl whose parents are on food stamps all in the same class. You have to be able to teach all of them as equally as possible but it requires a different strategy for each kid." (Y1)

While the issue of serving diverse needs and abilities was clearly an area of concern, Irvine felt that he had made a great deal of progress. In fact, he counted his growing skills in dealing with a wide range of students as his greatest success.

> "I started the year just going, 'good Lord, I have no idea with a class where I have an honors student and a special ed and 80% just regular students. How the heck do I teach all these kids?' But I have been able to kind of juggle four or five balls at once without stretching myself to the point of breaking. Just recently, I've noticed that the kids are getting everything in on time; the classes are running pretty smoothly; I've been dealing with discipline issues far less; so just kind of as that learning has gone on, I really feel that like I've accommodated pretty well." (Y2)

When discussing his teaching style and typical classroom activities in both years, Irvine reported consistent use of lecture as the primary instructional strategy. In the second interview, he recognized an over-reliance on lecture: "I think I started off the year, particularly on the block [schedule] with probably too much lecture" (Y2). Although lecture remained an important strategy in practically all classes, he had begun to consciously restrict lecture to thirty minutes and incorporate other activities designed to help students make conceptual connections from the day's material to the broader context of biology. This trend was reflective of Irvine's evolving perspective on the aims of science education. As mentioned above, Irvine positioned traditional,

lecture-based instruction as his ideal image of science education during year one. By the end of year two, his goals for high school science had shifted dramatically. He had become much less focused on disseminating facts to students and replicating college science classes and far more concerned with the kinds of personal meanings and relevance students created from their learning experiences. Irvine wanted students to understand how specific ideas fit into the larger theoretical frameworks of biology. He also wanted his students to draw connections between classroom science and their own lives. Irvine's focus on students' conceptual understanding and the relevance of science marked significant changes in how he approached science teaching. This change was easily the most dramatic difference observed in all of the cases examined between year one and two philosophies of teaching.

Case 3 Commentary

Irvine was typical of many preservice and novice teachers who come to education by way of the sciences. He began with a teaching philosophy informed by his own, successful experiences with lecture-based, traditional science instruction and prioritized student understanding of content over all other goals. As he struggled to work with students who were different from himself in abilities and interests, his singular focus on lecture and college preparation began to give way to more student-centered concerns including building personal understandings and helping students draw connections between science and their own lives. Despite progress in his relationships with students and his ability to teach a more diverse population, Irvine's long-term goals continued to include pursuing a science degree and teaching at the college level. The lack of peer and administrative support during Irvine's first two years of teaching may have contributed to this situation..

Case 4: The reflective teacher who received good mentoring—Oscar

Oscar went through the undergraduate preservice preparation program and possessed considerable expertise in physics and chemistry. He was obviously very bright, but his potential as a secondary teacher was questionable. At the outset of his student teaching experience, these concerns became reality as his high school chemistry classes began to spiral out of control. Oscar's cooperating teacher, an experienced educator and mentor, let his otherwise well managed classrooms slide into disarray for a couple weeks and then provided Oscar with a stark wake-up call. The cooperating teacher helped Oscar focus on classroom problems that had to be addressed and provided suggestions and support for making improvements, without taking back control of the classroom himself. From that moment throughout the rest of his internship and beyond, Oscar excelled in the classroom.

In year two, Oscar taught freshman level physical science and physics for students of advanced standing. He worked in a large suburban school similar in size and demographics to his student teaching placement; although, the two schools were in different states. Other than the initial student teaching phase during which he struggled with management issues, Oscar described his teaching practices in a consistent manner across both years. In describing his strengths, he noted an ability to connect with students on an individual level. He especially enjoyed connecting with otherwise unsuccessful students on a personal level: "I had no problem at all even reaching some of the hardest to reach kids as far as understanding the material. I had lots of success in that area." (Y1)

Another consistent trend across both years was his emphasis on reflection. He felt strongly about the need to carefully consider classroom problems and successes and to use these reflections as the basis for the improvement of his teaching

> "You have to sit down when you get home and think about what went well and what went really wrong and write it down … [if you don't do this] the things that go wrong be-

> come a habit. [By reflecting on it], tomorrow I'm gonna cross that off, its just not going to happen anymore." (Y2)

In both years, Oscar's classrooms tended to be student-focused and activity based. He strongly supported inquiry learning opportunities but, in both years, noted the difficulty of enacting these experiences. For his student teaching classes and his physical science classes in year two, Oscar reported devoting approximately 10% of his instructional time to inquiry-based activities and as much as 80% of the time to student activities with more direct teacher input or direction. However, Oscar employed inquiry based strategies for the vast majority of his instruction with the physics classes. These classes used a technology supported curriculum that provided students opportunities to model physical principles. Use of this curriculum predated Oscar's employment, and he received significant support from a teacher who had used the program extensively. Oscar was very happy with this curriculum and the learning taking place in his physics classes.

One of Oscar's primary goals for the future was transforming the school-wide physical science curriculum to provide more opportunities for learners to engage in science inquiry. He had been hesitant to suggest changes because of a perceived sense of investment on the part of his colleagues in the current physical science curriculum but was encouraged by the science department chair to proceed. This episode was emblematic of the very positive, collegial environment of the school. Oscar felt supported by his colleagues including the department chair, a formal mentor assigned by the school, and another experienced chemistry teacher who became a consistent source of ideas and encouragement. Oscar aired concerns, shared new ideas, and sought advice from these mentors on a daily basis. He obviously respected his colleagues and felt that they, in turn, valued his contributions and expertise. In discussing how he would approach the curriculum modification project, Oscar displayed a level of trust and mutual respect.

> "So he [the department chair] asked me what I thought [about the physical science curriculum] being the only one [of several physical science teachers] with extensive background in both [chemistry and physics] and I'm like 'it can be better.' And he asked me if I had ideas of how and I said, 'yeah… I have a lot of ideas'… [The department chair said] I want you to [modify the curriculum] because you're motivated and the other teachers that I work with said I have really good ideas and the whole thing… [Discussion continues regarding other teachers who may not want to change the curriculum]… I'm not worried about it, the department head wouldn't put me in a position to have my head bit off if I stepped on any toes." (Y2)

When asked to discuss how his ideas about teaching have changed over the previous two years, Oscar shared reflections that reveal a degree of development not frequently observed in first year teachers.

> "When I did my student teaching, I went from really idealistic to really—there are a lot of things that I learned in college or that I wanted to do…and they just can't happen based on curriculum constraints and classroom management. I think a lot of that had to do with the fact that I had never gotten up in front of this group of kids before and everything was so new and I was scared…Now I think it shifted a little bit more idealistic—I do think that a lot of the inquiry methods [will work]." (Y2)

Like many preservice teachers, Oscar's initial experiences with the realities of classroom instruction caused a reevaluation of his teaching philosophy. Unlike many of his peers, his first year teaching experience reinforced some of the student-centered, inquiry based practices advocated in his teacher education program.

Case 4 Commentary

Oscar was one of the brightest success stories of the group under investigation. Several of the participants may very well develop into outstanding teachers, but Oscar had already shown great progress in only two years. Two important factors stood out in Oscar's case: outstanding mentorship and active reflection. As both an intern and a first year teacher, Oscar received advice, support, and critiques from experienced educators willing to invest in another's career. This mentorship undoubtedly shaped Oscar's teaching in very positive ways, but the effect of the mentorship may very well have been multiplied because of his commitment to reflection. Other

teachers helped Oscar, and Oscar helped himself by carefully negotiating his experiences with the contributions of his mentors.

Case 5: The unremarkable teacher - Sal

As a preservice teacher, Sal did enough to get by; he attended class, submitted assignments, and met minimum expectations. He successfully completed prerequisite work and was eligible for student teaching but was informally designated as a student teacher to watch closely. In student teaching, Sal taught Biology and Life Science in a school with block scheduling. His cooperating teacher provided a lot of freedom and very limited mentoring; typical interactions involved a review of the day's lesson with little feedback. This particular set-up was not ideal especially considering the concerns associated with Sal's teaching potential, but ultimately, Sal completed, albeit rather unremarkably, his student teaching. In year two, Sal taught biology in a school situated in the urban-fringe of a moderate-sized city. He worked with ethnically diverse students of varying academic abilities and coached football.

Time management and appropriate planning were consistent challenges across both years. He cited problems keeping his materials and ideas organized and struggled to fill class time. It was not uncommon for Sal's planned instruction to run short leaving anywhere from five to fifteen minutes of down time before the class period's end. In both years, he attributed at least part of these problems to a lack of resources and equipment. In year two, planning issues were exacerbated by the challenge of traveling between two classrooms because of school construction.

Sal did not feel that he gained much in the way of mentoring during his student teaching, but he did recognize that the cooperating teacher shielded him from many of the time-consuming responsibilities of a classroom teacher. He had not dealt with school-wide meetings, parental

communication, interactions with administrators, and the seemingly endless stream of required paperwork. Adjusting to these realities of teaching became a significant aspect of Sal's transition to professional teaching: "There is definitely a lot more politics and other things involved with [teaching], not just teaching with everything else involved outside of the classroom" (Y2) Classroom management was another area that became a concern in year two. Sal inherited student teaching classes with in-tact routines that successfully handled most management issues. He reported struggling with establishing a management plan when he assumed his own classroom.

> "I didn't start off as a very hard-nosed person, and it kind of hurt me…the kids took advantage of that…I'm just learning. I'll be a lot tougher the first part of next year, which will give them an idea of what expectations I have, so they're not gonna push me." (Y2)

In both years, Sal discussed his ability to engage students in discovery learning and to reach students on a personal level as his strongest teaching attributes. On more than one occasion, he referred to his ability get the students "to understand what they do know even if they don't think they do" (Y2). In discussing typical classroom strategies and activities, Sal noted that most class periods involve some lecture followed by relatively short assignments or guided practice opportunities. Students worked on more extended projects at the end of each unit. During our observations, the class worked on one of these end-of-chapter assignments. Sal had committed four days, with the possibility of a fifth, for student pairs to create a poster or pamphlet outlining the processes of transcription and translation. For the most part, the students appeared unengaged and unmotivated by this activity. Sal reported that the observed classes were fairly representative of project days. Given our assessment of the day's lack of productivity and Sal's assertion, we are skeptical of his claim that students experienced a lot of discovery learning.

Unlike the student teaching experience, Sal reported positive interactions with his year two mentors. Sal met daily with his formal mentor and spent time with several informal mentors "bouncing ideas off of each other" (Y2). He did not provide more specific details regarding the

nature of the mentoring relationships. It was clear that Sal appreciated the interactions, but the quality of the mentorship provided was less clear.

Case 5 Commentary

Just as Sal's tenure as a student of science education was fairly unremarkable, his performance as a first year science teacher was unremarkable. He struggled with many of the issues novice teachers tend to note as problems including management, planning, and dealing with the complexities of modern schools. He talked about engaging students in discovery learning, but very little evidence emerged to support these contentions. Based on our analyses, Sal was not succeeding in significantly impacting student learning.

Case 6: The isolated teacher—Tara

Tara was an outstanding student. She completed the graduate preservice teacher program after having earned a bachelor's degree in geological sciences. She successfully completed all of the requirements in the preservice teacher program and really stood out in terms of creativity and her ability to critically reflect on her own practice. Not surprisingly, Tara did a great job in her student teaching placement. As a student teacher, she taught middle school science and worked with an experienced educator who felt strongly about letting Tara create her own path. As such, she experienced a lot of freedom in all aspects of her internship teaching including management strategies, lesson planning and instructional implementation. Tara appreciated this freedom and viewed the experience as a confirmation of her desire to teach. Even though the cooperating teacher took a hands-off approach in the classroom, she did involve Tara in school-wide activities including long-term planning efforts and professional development initiatives. Tara became an active part of the school community and shared strong working relationships with many teachers.

Tara's full-time teaching position the next year presented a very different context. She worked in a much larger high school and taught five periods of earth science. She openly struggled with feelings of isolation and a lack of support from other teachers and the science department as a whole. To get any useful advice, Tara really had to go out of her way to seek help from experienced colleagues in other departments and from other parts of the building. Beyond the struggle of not feeling personally connected to her colleagues, Tara's biggest challenge was dealing with the negative reputation of the course she inherited. The earth science course she taught had long carried very low expectations for academic performance and student behavior. Students enrolled in the class expected to do very little, and Tara felt that her colleagues possessed equally low expectations for her and her students. These ideas clearly did not match Tara's own expectations and had become a continual source of tension for her.

One implication of these divergent expectations was difficult classroom management. Many of Tara's students came into the class thinking they could engage in a lot more off-task behavior than Tara found acceptable. Even though the contexts were quite different, Tara wrestled with the same kind of issue underlying classroom management in both the student teaching placement and the first year of full-time teaching. In both situations she struggled with consistency and knowing when to enact consequences:

> "I wasn't as strict with second [period] and so by the end, they were just about driving me nuts. Being consistent even when the class seems to be well behaved—I think making sure that you always follow through is important." (Y1)
>
> "I'm having trouble in deciding where to draw the line and when to give them a detention—like when to send them down to the office or like how far should I go…It's hard for me to decide, you know, when I tell them once to get to work or put that down… I haven't quite figured that out yet." (Y2)

Tara's perceptions of her own teaching also remained consistent. In both years she discussed a tendency to prioritize group work and projects and minimize teacher-directed lectures.

Group and individual projects in which students work to find information about topics of interest followed by opportunities for them to share their results seemed to be the most important mode of instruction. This was supported during the researchers' classroom observation: the majority of class time was devoted to student presentations and the classroom walls were covered in student-generated posters. Several tables around the room were also stacked with posters and other visual projects awaiting grades or student pick-up.

Overall, Tara was proud of the work her students were doing: "Some teachers kind of looked at me like, 'you're having them do what?' And I was like, 'they'll do it, I guarantee you, we'll get those done.' And I had a lot of really good presentations" (Y2). However, she seemed less certain than she had been at the conclusion of her student teaching that she would actually stay in the teaching profession. She seemed to like many aspects of teaching but found it very challenging and suffered from not having quality mentors around to support her professional development. One year following the second interview, Tara was actively seeking a teaching position in a different county as well as admission to a full-time graduate program in higher education administration.

Case 6 Commentary

Tara's case was easily the most disappointing. At the outset of this research, Tara showed outstanding teaching potential and demonstrated a commitment to the teaching profession. She excelled in the preservice program and student teaching. In year two, she was constantly striving to raise the expectations of colleagues and students for her classroom, but found herself isolated and left with a feeling of swimming upstream. Although Tara was assigned a formal mentor during her first year of full-time teaching, and was a participant in a district-wide mentoring program, Tara's case is an example of how a lack of follow-through leaves teachers behind. After

losing her first mentor to unforeseen circumstances, Tara was left without any formal support for the remainder of the year. Unfortunately, she found herself in an unsupportive environment and appeared to be searching for ways out of teaching. We can not help but wonder about how her career trajectory might differ if she had received mentorship and collegial support.

Pragmatic Concerns

During the year two interviews, participants were asked to reflect on factors which they believed had been helpful in their preparation as professional educators. They were also asked to make recommendations for teacher education programs. For the most part, the responses to both of these questions highlighted pragmatic concerns. These early career teachers were very focused on the daily routines of their classrooms and tended to concentrate on reflections and suggestions directly applicable to their own classroom settings. Reflective of this trend, all of the participants underscored the practical benefits provided by the student teaching experience. Sal's comment below was characteristic of the sentiments expressed by all of his peers involved in the study:

> "Student teaching helped me a lot with getting, understanding more of what I'm supposed to be doing in the whole classroom setting, and they gave me sort of an environment instead of being in a college class, teaching college students. You're teaching the high school students so it gives me a better idea of what I need to do." (Y2)

Several participants also recognized specific aspects of their preservice education program and coursework as important components of their professional preparation. They talked about the value of learning about instructional strategies, learning theory, lesson planning, assessment strategies, and state and national standards. One individual teacher also talked about how her education coursework had prepared her to deal with the complexity of schools and to better handle long-term, iterative cycles of planning and progress.

> "In a lot of my classes we talked about trying to maintain a positive attitude and that can be very challenging at times and the kids really, they really pick up on it really quickly if you are having a bad day or if things are really frustrating… Mentally knowing that your first year is not easy and like trying to find like your lessons, 'well that sure didn't work

> very well but let's see what did work and pull those out.' You know not to scrap what you're doing; I'll probably change the format next year. I'll take little steps and build more on top of those [initial difficulties." (Tara, Y2)

While most of the participants discussed aspects of their educational coursework when asked about what had been helpful in their professional preparation, Irvine concluded that coursework had not meaningfully contributed:

> "I could probably take all the courses that had to do with education and stuff and just throw them to the side and just take the student teaching experience…All the theory and methods and all that is so detached it's almost like it doesn't make sense at all once you're actually into the application." (Y2)

In contrast, Oscar presented a very different appraisal of the preservice training:

> "The stuff that I did in school did [help prepare me for teaching], even if at the time it was sort of hard. [I thought], 'OK, why am I learning this right now?' But you get into school and you get into a classroom and you look back at your binders or whatever and all of a sudden there is something that, 'oh yeah I remember this; this will work tomorrow.'" (Y2)

When asked to provide specific recommendations for the training of future science teachers, the participants extended their focus on the pragmatic. The single most common suggestion was to provide as many lesson, activity, and laboratory ideas as possible. One of the consistent challenges for most of the participants was finding/generating high quality lessons for their students, and these beginning teachers would have liked their preparation program to have provided more in the way of specific classroom resources. A few of the participants also suggested helping preservice teachers understand and learn to deal with the complexities of real schools and classrooms. Here, respondents were referring to all the little things that go along with teaching that novices typically do not expect like dealing with school policies, attendance, tardies, school politics, parental communication, etc. Other training recommendations included providing more information on classroom legal issues, strategies for teaching students with mental and physical disabilities, teacher grants, classroom management, and state certification requirements. Although the vast majority of responses to this prompt focused on pragmatic information which

reflected the respondents own struggles, Oscar provided a recommendation which rose above his immediate circumstances. He suggested an even stronger focus on critical reflection. Reflection had become a part of Oscar's own teaching routine, and he saw it as a critical catalyst for the development of early-career educators.

Where Are They Going?

Over the two year span of this investigation, fourteen participants provided data. Of these individuals, all of whom successfully graduated with either a bachelor's or master's degree and completed a science teacher preparation program, ten accepted middle or high school science teaching positions in year two. One participant accepted a position coordinating labs and teaching undergraduate chemistry classes at a local university. Another participant took a position as a curriculum specialist with a university-based curriculum and assessment organization. One participant moved to a small town and worked as a substitute teacher because he could not find a teaching job. The remaining participant began a graduate program in environmental education.

In the investigation's second year, data were collected regarding how participants expected their careers to develop. Data were available from twelve participants. Just over half (seven) saw themselves working as science teachers in middle or high school contexts. Two participants planned to become school administrators, and another two were pursuing graduate programs with plans to teach at the college level. The participant enrolled in the environmental education during year two planned to work as an educator in an informal setting. Table 1 presents relative proportions of participants involved with science teaching in year two as well as their plans for the future.

Table 1. Participant activities in year 2 and future plans.

	Science Teaching (MS & HS)	College Teaching	Graduate School	Seeking a Teaching Position	Curriculum Specialist	Informal Educator	School Admin.
Year 2	72%	7%	7%	7%	7%	--	--
Long-term Plans	58%	17%	--	--	--	8%	17%

Discussion

In discussing the results, we turn first to the data presented at the end of the previous section, which document what the participants in the original report (Sadler, 2006) were doing in the year following their teacher preparation program and their plans for the future. At first glance, these data provide additional evidence of growing concerns related to a lack of highly qualified science teachers. In the first year following a teacher preparation program, over 25% had not taken K-12 teaching positions. When these same individuals considered their future plans, just under half saw themselves in positions other than as classroom teachers. However, a closer look at these data suggests a more complex picture. At both time points (year two and the long-term future), all of the participants were (or planned to be) involved with some aspect of education. While this may not alleviate the problem of K-12 science teacher shortages, it does offer a different perspective on the "flight" of early career teachers (NCEI, 2005) from the classroom.

Many research reports related to science teacher education have documented the gap between beliefs about learning and intentions to employ student-centered pedagogies, on one hand, and actualized teaching practices on the other hand (e.g., Crawford, 1999; Eick & Reed, 2002; Koballa et al., 2005; Levin & Ammon, 1992; Simmons et al., 1999). We found evidence to support this problem, but the breadth of our case studies sheds new light on the issue. In the case of

Sal, we found a teacher, who talked about embracing student-centered pedagogy, but did not make effective use of these strategies in his classroom. There was a gap between intentions and practice for Ella as well, but she knew and acknowledged the gap existed. Whereas Sal reported that he successfully engaged students in inquiry, Ella recognized that she was not implementing student-centered pedagogies nearly as well as she would have liked. Like teachers documented in other studies (Owen, Johnson & Welsh, 1985; Roehrig & Luft, 2004, Volkmann & Anderson, 1998), Ella attributed her lack of success to factors such as limited resources, classroom management issues, and under-prepared students. Tara encountered additional constraints that are not discussed in previous research nearly as much as some of the others just mentioned. Tara struggled against the expectations of her students and colleagues. The students and other teachers expected very little from Tara's classes, and she felt that this became a serious impediment to effective instruction. On the other end of the spectrum, Oscar's case offers evidence of successful implementation of inquiry learning by a beginning science teacher. The supportive school environments in which Oscar worked was an important factor for his success. While not alone, this is one of a few documented cases (Crawford, 1999; Eick & Reed, 2002) in which beginning teachers successfully adopt inquiry teaching strategies.

Another frequent topic in the teacher education literature has been the extent to which teacher preparation programs effectively contribute to beginning teachers' professional development. While some evidence has been reported documenting the positive effects of university-based preparation programs (Beeth & Adadan, 2006; Levin & Ammon, 1992), several reports have documented that beginning teachers tend not to feel as though their teacher education programs served them well for the challenges of actual teaching (Adams & Krockover, 1997; Kagan, 1992; Wideen et al., 1998). Here again, our set of cases reveals underlying complexities. All

of the participants strongly endorsed their field experiences, including most notably the ten–week student teaching, but they expressed diverse perspectives on the utility of the university-based coursework. On one end of the spectrum, Irvine felt that his education coursework was useless. In contrast, Oscar found the coursework to be quite useful and attributed his preservice experiences as one of the factors contributing to his success. This highlights an important challenge facing science educators trying to address the perceived needs of students like Irvine, who may resist the goals of education coursework, and students like Oscar, who embrace the message of reform-oriented methods courses.

The Effect of Mentorship

When we began this project, a primary aim was to generate data to inform the continued improvement of the science teacher preparation program to which we contributed. While we have used the resultant findings to modify, and hopefully improve, our program, the most important implications of this work relate to issues that cannot be addressed through university-based teacher education. To be clear, we are not lending credence to the growing voices (often politically motivated, in our opinion) which challenge the role of colleges of education in the preparation of teachers. We believe strongly in the mission of teacher education and believe that teacher education programs staffed by pedagogical and curricular experts provide unparalleled contributions to our system of education. However, our findings draw sharp attention to the effects of mentorship particularly during the induction phase when beginning teachers are no longer formally associated with teacher preparation programs.

This study is by no means the first to suggest that mentorship for beginning science teachers is important (see Anderson, et al., 2004; Davis, Petish & Smithey, 2006; Ensor, 2001; Luft & Patterson, 2002; Volkmann & Anderson, 1999). However, the longitudinal nature of our

work and the contrasts among individual cases of teachers, who participated in a common teacher preparation program but experienced very different teaching contexts, offer a new window into the effects of mentorship for beginning science teachers. To illustrate this point, we call attention to the cases of Oscar and Tara. At the beginning of their teacher preparation program, Tara and Oscar demonstrated very strong science content backgrounds and creativity. Tara performed very well in her student teaching practicum and experienced very supportive school and classroom environments. After a rough start, Oscar also did very well as a student teacher in large part because of some well-timed advice from his cooperating teacher. By the end of year one, both participants looked forward to beginning careers as science teachers. Tara and Oscar began their teaching careers in very different settings, and the most ostensible difference was the level of support they received from their schools and colleagues. Oscar found himself surrounded by supportive colleagues eager to share ideas, listen to problems, and offer advice. In contrast, Tara felt completely isolated with no mentorship and very limited support. By the end of year two, Oscar, with the backing of his department, was making plans to overhaul the 9th grade physical science curriculum. By the end of year two, Tara was searching for ways out of her classroom through another school or another career.

Mentorship emerged as an important issue in other cases as well. Like Oscar, Sal worked in a very supportive environment during year two and received formal mentorship. Unlike Oscar, Sal appeared less ready to strongly benefit from that mentorship. Whereas Oscar entered the teaching profession with well-developed notions of student-centered pedagogies, Sal seemed only able to pay lip service to these ideas. The mentorship that Sal received may have eased his transition into the profession, but there was no evidence of it significantly enhancing his teaching. In Oscar's case, a well-prepared beginning teacher found himself in an environment with

experienced educators willing to share their expertise and committed to ideas and pedagogies consistent with Oscar's perspectives. Oscar espoused inquiry-based teaching practices and worked with colleagues who also valued this approach. Oscar's own commitment to self-improvement and reflective teaching practice very likely intensified the positive effects of mentoring.

Like Tara, Irvine did not work in a supportive environment and did not receive formal mentorship. By the end of year two, both of these beginning teachers were looking for ways out of their teaching positions. Both had expressed some interest in considering positions at other high schools, but both were actively applying for graduate school admission by the end of their first year of full time teaching. Irvine's situation was not all that surprising because he had talked about going on to study graduate-level biology during the year one interviews. From the very beginning of this project, Irvine was more committed to research biology than teaching in secondary contexts. Mentoring would have very likely made Irvine's teaching experience more positive, but we can only speculate on the possible effects it would have had on his long-term career choices. On the other hand, Tara's difficult first year as a teacher and lack of collegial support seem to have driven a very promising science educator from the field. When we last checked, Tara was making plans to attend graduate school for studies related to higher education policy and administration.

Conclusions

In their recent review of literature related to science teacher education, Davis et al. (2006) call for longitudinal studies of the development of beginning science teachers. The current study answers this call by following fourteen teachers as they transition from students of science education to teaching professionals. Our work confirms several findings from previous reports. The

transition into the profession of teaching can be quite challenging particularly with respect to how novice teachers deal with the complexity of modern schools, classroom management, diverse student bodies, and incorporating opportunities to engage students in authentic inquiry. Our work also extends this literature by documenting consistency in the teachers' beliefs about teaching and idealistic notions of what science education should entail during this transition period. This research also reveals layers of complexity in terms of the retention of beginning teachers in the field, the gap between beliefs about science teaching and teaching practice, and teachers' perspectives on preservice training programs. Comparative analyses of various cases highlight the significance of mentoring for beginning science teachers. As mentioned earlier, we initiated this project with a goal of understanding how to improve our science education programs. We conclude this project with new questions regarding how mentorship for beginning science teachers can be increased, supported, and enhanced. How can teacher education programs and beginning teacher induction programs be better aligned to ultimately support beginning teacher experiences? How can effective mentors be optimally recruited, trained, and retained? What aspects of mentorship are most important for successfully supporting beginning teachers, and how can these aspects be promoted?

Appendix A: Year Two Interview Protocol

1. Please describe your teaching context. What kind of school are you working in? How would you characterize the students you are working with? How would you characterize the teaching environment?

2. What kinds of school activities are you involved in beyond your classroom responsibilities? How do you see yourself in relation to the rest of the school and other faculty members?

3. What has been challenging about your first year of teaching?

4. How have you succeeded in your teaching? What are you good at in terms of teaching? What areas of your teaching do you still need to work on?

5. How would you characterize your teaching? What does a typical day look like in your classes?

6. In an ideal world what should science teaching look like? How does your teaching differ from this ideal?

7. How have your ideas about teaching changed over the last year?

8. What has been most helpful in terms of preparing you for the profession? (If the participant does not mention any of the following, ask for their impressions of mentorship at the school; school-wide or district-wide induction programs; their student teaching experience; and their preservice training program.)

9. Knowing what you do now, what recommendations do you have for science teacher training?

10. Where do you see yourself professionally in 5 years? Where do you see yourself professionally in the distant future (15-20 years)?

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