Developing Orientations

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Do Beliefs Change? Investigating Prospective Teachers’ Science Teaching Orientations during an Accelerated Post-Baccalaureate Program

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Abstract
Science teaching orientations have been theorized as a critical component within the Pedagogical Content Knowledge (PCK) model of science teacher knowledge. However, few empirical studies investigate the nature and sources of science teaching orientations. The purpose of this study was to investigate how science teacher orientations develop in an Accelerated Post-Baccalaureate master’s program leading to science teacher certification. Data sources included a lesson planning task at the beginning of the program, interviews after the first summer of coursework, an interview-observation cycle during the prospective teacher’s first and second semester teaching, and interviews with the mentor teachers. We constructed profiles of four prospective and four mentor teachers and generated a set of assertions from a cross-case analysis. The prospective teachers’ science teaching orientations were complex, consisting of multiple dimensions. Although each prospective teacher added goals and/or views of the teacher’s role, their science teaching orientations were highly resistant to change. The mentor teacher had the greatest impact on prospective teachers’ science teaching orientations, and in particular, on the elaboration of goals and views of the teachers’ role.
Introduction

Inquiry-based science (National Research Council [NRC], 1996) is at the core of reform in science education in the U.S. and in other parts of the world. Proponents of inquiry-based science support instruction that emphasizes the role of questions, evidence, and explanation in science (Bybee, 1997). Reform-based pedagogy in science requires that students actively participate responding to scientific questions, giving priority to evidence, and formulating and justifying explanations (NRC, 2000). Preparing prospective science teachers to enact this vision of science education reform is one of the roles of teacher educators.

While this vision of science pedagogy dominates the literature on K-12 education and is the focus of most science teacher preparation programs, researchers have found that classroom practices of teachers across the U.S., and in other countries, are far from achieving this vision. For example, results from the 1999 TIMSS video study of eighth grade science in five countries included the following commonalities in science instruction (Roth et al., 2006, no page number):

- Whole-class seatwork (i.e., presentation and discussion periods) occurred in at least 98 percent of eighth-grade science lessons in all the countries, and at least some time was spent developing new science content in 95 percent or more of the lessons.
- Knowledge about the nature of science (i.e., its values, dispositions, processes, politics, or history), meta-cognitive strategies (i.e., learning strategies or reflecting on the learning process), and safety accounted for no more than a combined total of 2 percent of public talk time (sections of the lesson when the intended audience of the teacher or student speaking was the whole class) in any of the countries. Science canonical knowledge was more prominent in the science lessons of all five countries than any other type of science knowledge investigated.
- Although the percentages of science lessons and instruction time allocated for student independent work on practical activities varied across the participating countries, students in all the countries were more likely to observe phenomena during independent practical activities rather than to design and make models, to carry out dissections or classification activities, or to conduct controlled experiments.
- Students generated their own research questions and designed procedures for practical investigations in no more than 10 percent of lessons in countries with sufficient observations to calculate reliable estimates.

Why is there this disconnect between what reformers, researchers, and teacher educators value and the practices we typically observe in schools? What is the weak link between science teacher preparation and resulting teacher practices? We believe that more research related to the development of teacher knowledge and beliefs will help us to identify factors critical to supporting reform efforts. The past 30 years in teacher education research mark a shift from identifying aspects of effective teacher training to understanding the factors that influence the development of teacher knowledge (Cochran-Smith & Fries, 2006). A number of studies highlight the important role that teachers’ background experiences have on teachers’ beliefs about teaching and learning (Nespor, 1987; Pajares, 1992). The purpose of this study is to understand the development of prospective science teachers’ knowledge and beliefs about science teaching during a post-baccalaureate teacher certification program in order to explain their practices.
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Theoretical Framework

In 1986, Lee Shulman proposed a model of teacher knowledge emphasizing that teaching requires more than just subject matter knowledge. Teaching is a complex process requiring teachers to transform and apply knowledge from multiple domains. Shulman (1986) described seven domains of teacher knowledge to include: “(a) content knowledge; (b) general pedagogical knowledge; (c) curriculum knowledge; (d) pedagogical content knowledge; (e) knowledge of learners; (f) knowledge of educational contexts; (g) knowledge of the purposes, philosophy, and historical grounds for education” (p. 227). Shulman emphasized that effective teachers blend both content and pedagogical knowledge, and transform them into knowledge specific to teaching called Pedagogical Content Knowledge (PCK). According to Shulman (1986), PCK is “teachers’ cognitive understanding of subject matter content and the relationship between such understanding and the instruction teachers provide for students” (p. 25). Thus, PCK is a form of teacher knowledge, distinct from other domains of teacher knowledge, but defined by its relationship to those other domains. Shulman’s view of teacher knowledge emphasized that teaching requires individuals to draw from many sources to develop knowledge for teaching. Additionally, this view stresses the importance of teacher preparation because teacher knowledge is learned through educational courses and developed through experiences with students. Studies of teacher knowledge have shown that knowledge of content and pedagogy influence how teachers teach (Ball, 1991; Davis, Petish, & Smithey, 2006).

Grossman (1990) built on these ideas to highlight the relationship among three knowledge domains that influence a teacher’s PCK. These knowledge domains include: (1) subject matter knowledge and beliefs, (2) pedagogical knowledge and beliefs, and (3) knowledge and beliefs about context. According to Grossman, PCK is knowledge that is transformed from these three knowledge domains and is more powerful. Grossman (1990), in her study of beginning teachers, reported that PCK is developed from the following sources: (a) observation of classes as a student and teacher, (b) specific courses during teacher education, and (c) classroom teaching experience. Grossman’s PCK model includes four components. The first overarching component, “conceptions of purposes for teaching subject matter,” acts as a filter for the other three components: knowledge of students’ understandings, curricular knowledge, knowledge of instructional strategies,

Magnusson, Krajcik, and Borko’s work (1999) further elaborated on Grossman’s model of PCK. Magnusson et al. (1999) described PCK as:

A teacher’s understanding of how to help students understand specific subject matter. It includes knowledge of how particular subject matter topics, problems and issues can be organized, represented, and adapted to the diverse interests and abilities of learners, and then presented for instruction. (p. 96)

Magnusson et al. (1999) proposed a PCK model for science teaching that conceptualized PCK as consisting of five components: (1) orientations toward science teaching, (2) knowledge of curriculum, (3) knowledge of assessment, (4) knowledge of students’ understanding of science, and (5) knowledge of instructional strategies (see Figure 2). This model retains many of the components of Grossman’s (1990) model, with two changes. First, the component of knowledge of assessment is an addition. Second, Grossman’s overarching component of “conceptions of purposes” is identified by a new term, “orientation to teaching science.” Magnusson et al. preferred the term “orientations to teaching science,” drawing on the work of Anderson and Smith (1987) in science education. Although terminology changed, the role of this component
remained the same – shaping and being shaped by the other components. Hence, orientations to teaching science are theorized to play a pivotal role in the PCK model, guiding teachers’ instructional decisions.

In examining the “orientations to teaching science component” of the PCK model for science teaching, an issue arises with the definition of this component. Magnusson et al. (1999) retain Grossman’s original definition for conceptions, i.e., “a teacher’s knowledge and beliefs about the purposes for teaching science at a particular grade level” (p. 97) while also including Anderson and Smith’s (1987) broader definition of, “a general way of viewing or conceptualizing science teaching” (p. 97). So, in changing terminology and drawing on both the work of Grossman (1990) and Anderson and Smith (1987) the definition of orientations to science teaching becomes ambiguous.

To bring clarity to this definition, we have drawn on the mathematics education literature (Ernst, 1989; Handal, 2003). Building on this literature, we have expanded Magnusson et al.’s definition of science teaching orientations to include the following dimensions: beliefs about teachers’ goals and purposes for teaching science, views of teaching and learning, and views of teacher/student roles in the science classroom. Researchers have used the term “dimensions” when referring to teacher/student roles and goals and purposes for teaching science (Koballa et al, 2005; Samuelowicz & Bain (1992). By elaborating Magnusson et al’s definition of orientations, we take a more fine-grained view of the development of prospective teachers’ beliefs within a teacher education program.

Research Questions

This study is part of a larger study that examined the development of prospective teachers’ PCK during an Accelerated Post-Baccalaureate master’s program resulting in teacher certification. The larger study examined the relationship of orientations to teaching science with two other PCK components: knowledge of students’ understanding of science and knowledge of instructional strategies with a focus on sequencing of instructional strategies within a lesson (Brown, 2009). This paper focuses only on the orientations to teaching science component of the larger study. The research questions guiding this study are: (1) How do prospective teachers’ science teaching orientations develop during the post-baccalaureate program; (2) What is the nature of prospective teachers’ science teaching orientations at different points in time in their teacher education program (entry, end of summer, fall/spring semester); and (3) During the post-baccalaureate program, what sources influence prospective teachers’ science teaching orientations?

Review of the Literature

Researching teachers’ science teaching orientations was inspired by research that demonstrates the important role that background experiences have on prospective teachers’ beliefs about teaching and learning (Calderhead, 1986; Da-Silva, Mellado, Ruiz, & Portlan, 2006; Kagan, 1992; Lortie, 1975; Nespor, 1987; Pajares, 1992). Investigating teachers’ beliefs is important because researchers theorize that they influence practice. Borko and Putnam’s (1996) review of the literature on how teachers learn to teach proposes that teachers’ beliefs act as a “conceptual map” that guides instructional decisions and practice. A substantial body of research suggests that teachers’ knowledge and beliefs have a profound impact on all aspects of their teaching (Ball, 1991; Carlsen, 1991; Davis, Petish, & Smithey, 2006; Nespor, 1987).
Developing Orientations

Research on science teacher orientations is complicated by the wide variety of labels and terms used by researchers to describe teacher beliefs. Anderson and Smith (1987) used the term “orientations” to describe teachers’ “general patterns of thought and behavior related to science teaching and learning” (p. 99). They identified four orientations that describe different approaches to science teaching: (1) activity-driven, (2) didactic, (3) discovery, and (4) conceptual change. Hewson and Hewson (1987) described “conceptions of science teaching as:

- Set of ideas, understandings, and interpretations of experience concerning the teacher and teaching, the nature of content of science and the learners and learning which the teacher uses in making decisions about teaching, both in planning and execution. (p. 194)

Grossman’s (1990) described “conceptions of purposes for teaching subject matter” in her PCK model (p. 5) as reflective of teachers’ goals and purposes for teaching particular subjects. As stated earlier, Magnusson et al. (1999) defined “orientation to teaching science” as “teachers’ knowledge and beliefs about the purposes and goals for teaching science at a particular grade level” (p. 97) as well as a “generalized way of viewing or conceptualizing science teaching” (p. 97). Magnusson and her colleagues identified nine different science teaching orientations: (1) process, (2) academic rigor, (3) didactic, (4) conceptual change, (5) activity-driven, (6) discovery, (7) project-based science, (8) inquiry, and (9) guided inquiry.

In studying the factors that contribute to the development of teachers’ science teaching orientations, researchers have investigated background experiences, teacher preparation, and teaching experience. Some studies investigate the origins of teachers’ science teaching orientations (Da-Silva et al., 2006; Koballa et al., 2005; Anderson et al., 2000). Koballa et al. (2005) found that alternatively certified teachers' conceptions about science teaching and learning were formed by their prior experiences. In the context of an elementary teacher preparation program, Anderson et al. (2000) studied three prospective elementary teachers’ development of “conceptions of teaching.” In their study they used a metaphor using the terms “trajectory” and “forces” to describe the development of prospective teachers’ orientations. They reported that participants in their study came into the program “already moving along a particular trajectory, seeking to learn about certain aspects of teaching that were congruent with each one’s own current conceptions of good teaching and learning” (p. 567). Da-Silva et al. (2006) studied how an experienced science teacher named Consuelo developed “conceptions of science teaching and learning” over a 9-year time span. Consuela began her teaching career believing that science teaching was mainly transmitting knowledge, based on her experiences as a student observing her teachers. For example, Lortie (1975) used the phrase “apprenticeship of observation” to describe the well-formed beliefs about teaching and learning that prospective teachers bring to teacher preparation based on their K-16 experiences. Lortie argued that success in K-16 science courses provides strong evidence for prospective teachers’ beliefs about teaching and learning.

A few studies have investigated the influence of a teacher preparation program on the development of prospective secondary prospective teachers’ orientations (Koballa et al., 2005; Lemberger, Hewson, & Park; 1999; Marion, Hewson, Tabachnick, & Blomker, 1999). Lemberger, et al. (1999) studied prospective secondary science “teachers’ conceptions of science and science teaching.” The three participants in their study believed that a goal of teaching science is to ensure students receive factual information. The teachers used metaphors like “throwing out” or “taking in” information to talk about the responsibility that teachers have in transferring factual knowledge to students (p. 369). The teacher preparation program did little to

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change their beliefs about teaching and learning. Hewson and colleagues investigated the development of teacher knowledge of conceptual change approaches across an entire teacher preparation program. They found that although teachers in their study learned about conceptual change approaches in methods courses, they were unable to use them in practice (Lemberger, et al., 1999; Marion et al., 1999). In Koballa’s et al.’s study the researchers identified five “conceptions” about science teaching held by secondary science teachers in an alternative certification program. These conceptions included: (a) presenting science content to students, (b) providing students with a sequence of science learning experiences, (c) engaging students in hands-on science activities, (d) facilitating the development of students’ understandings about science, and (e) changing students’ science-related conceptions. Similar to Lemberger’s study, Koballa et al. reported that teachers were reluctant to change their conceptions of teaching science during teacher preparation.

Research also suggests that science teaching orientations can change with teaching experience and according to the teaching context. In Da-Silva et al.’s (2006) study, as a result of teaching experience, Consuelo’s “conceptions of science teaching” shifted from a teacher-centered, traditional-transmission view, to a more constructivist model that focused on procedures and student learning rather than stressing concepts. Friedrichsen and Dana (2005) studied the unique contextual influences of the school and teaching setting on four highly regarded, experienced biology teachers’ orientations. The researchers reported that biology teachers’ orientations to science teaching were complex and shifted based on the course and grade level of the student, and informed their implementation of specific instructional strategies. These studies connect to our research and suggest that orientations to science teaching are complex and can change with time and experiences.

Orientations are theorized to play a pivotal role in the Magnusson et al. (1999) PCK model for science teaching. However, our review of the literature revealed that very little research has been done to investigate how components of teacher preparation (Secondary Science Methods Courses and field experiences) contribute to the development of prospective secondary teachers’ science teaching orientations. Thus, investigating the development of secondary prospective teachers’ science teaching orientations could shed light on how beginning teachers interpret and assess ideas and experiences they encounter during teacher preparation.

Research Design

The participants in this study enrolled in an Accelerated Post-Baccalaureate (APB) and their four respective mentor teachers. The APB program is designed for individuals with an undergraduate degree in science or a related area who desire a high quality teacher preparation program in an accelerated time frame. The prospective teachers attend two concentrated summer sessions on campus and spend one school year as interns in a guided setting at a partner school (20 hours per week), during which they take coursework and are part of a learning community with other interns, mentor teachers, and faculty members (see Table 1).

[Insert Table 1 about here]

The prospective teachers in the APB program enroll in three Secondary Science Methods courses. The nature of science, the nature of science learning, and the nature of science teaching are common themes across the three courses. Within these three areas, the courses highlight
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reform-oriented science teaching orientations (e.g., inquiry, conceptual change, problem-based learning) that view teaching and learning as the construction of knowledge based on students’ firsthand experiences collecting data. Table 2 shows the Secondary Science Methods instructors’ goals addressed in each course.

[Insert Table 2 about here]

For this study, we purposively selected four secondary biology APB prospective teachers (Jason, Mary, Amy, and Lilly). The participants were representative of individuals in the APB, most of whom seek secondary biology certification. In addition, we selected secondary biology as the subject area because the first author’s background is biology teaching (Patton, 2002). Shulman (1986) highlighted the importance of the researcher having a strong background in the specific subject matter as PCK is a specialized knowledge base for teaching that draws upon an individual’s knowledge of subject matter. Differences among participants included self-reported prior experiences with children and experiences that reflect their organizational leadership. For example, Jason had served as a Boy Scout instructor and Young Life Leader; Mary had been a nanny and camp counselor; Amy was employed as a permanent substitute teacher for grades K-12, worked as an assistant soccer coach, and was a camp counselor; and Lilly was an after school tutor and a mentor with the Big Brothers Big Sisters program and Women of Worth (WOW).

This study took place during the first three semesters of the APB program (i.e., the first summer, fall and spring semesters). To document incoming PCK, we used the Lesson Preparation Method based on Valk and Broekman (1999). Numerous researchers have implemented the Lesson Preparation Method to investigate prospective teachers’ conceptions and concerns about teaching content at a specific grade level (De Jong, Ahtee, Goodwin, Hatzinikita, & Koulaidis, 1999; Frederik, Valk, Leite, & Thoren, 1999; Friedrichsen, Abell, Pareja, Brown, Lankford, & Volkmann, 2009). Participants designed two 50-minute lessons for 8th graders that addressed the following topic, “There is heritable variation within every species of organism.” Following the lesson planning task, we conducted a semi-structured interview (Patton, 2002; Seidman, 1998) with each ABP teacher targeted at understanding their orientations and topic-specific PCK for learners, instruction, curriculum and assessment. At the end of the first summer of the ABP, we conducted a second semi-structured interview to allow the teachers to review, reflect on, and change their initial lesson plan. During the school year, we conducted an observations cycle during each of the two semesters. The observation cycle consisted of the following: a pre-observation interview, two consecutive field observations, and two stimulated-recall interviews. We also conducted two semi-structured interviews with the mentor teachers, one in the fall and one in the spring. All data collection instruments are available at the project’s website (http://resmar2t.missouri.edu.html).

Data Analysis

The process of constructing cases occurred in two phases. In the initial phase, for each participant, we combined the raw data from multiple data sources. To analyze the resulting data sets, we used coding categories that emerged from our theoretical framework. The coding scheme consisted of six major categories (see Table 3). Additionally, in examining teachers’ goals, we classified their goals a central or peripheral (Friedrichsen & Dana, 2005).
Based on the coded data, the first author created individual summary cases for each participant (within-case analysis). The cases were read and checked by the other two authors. Any discrepancies were discussed and resolved within the research team. The individual cases facilitated data reduction and provided a synthesis of each participant's data (Denzin & Lincoln, 2005). Triangulation was achieved through multiple data sources, lesson plans, interview transcripts, and field observations (Yin, 1994), as well as through multiple researchers (Denzin & Lincoln, 2005).

In the second phase of the data analysis, we analyzed the four participants' cases for patterns and themes that occurred across all four cases (cross-case analysis). The first author generated tentative assertions that were tested during team research meetings, with all members of the research team checking the data to look for confirming and conflicting evidence. Cases for each of the four participants and their mentor teachers were checked in this manner. We revised the assertions until agreement was reached among the three researchers.

Interpretations

We present our interpretations in two sections. In the first section, we use individual cases to show the prospective teachers’ science teaching orientations, including images of science teaching and learning, goals, teacher roles, and student roles. Additionally, we provide profiles of their mentor teachers’ orientations to science teaching. The individual and mentor teacher profiles provide a context for understanding the factors contributing to the development of prospective teachers’ science teaching orientations. In the second section, we present our cross-case analysis addressing the research questions related to the nature and development of prospective teachers’ science teaching orientations.

Mary’s Case

Experiences Prior to Program

Mary, age 23, did not initially plan to become a high school science teacher. Although Mary had not taught in a formal setting, she enjoyed “helping others, by explaining ideas and sharing knowledge.” She viewed teaching as a fulfilling and worthwhile career based on her experiences as a tutor and nanny. Mary entered the APB program immediately after graduating from a large Midwestern institution with an undergraduate degree in biology.

Entry

Mary’s images of teaching were based on her experiences as a student. She was taught science in a traditional, delivery mode. She explained, “The majority of my classes it was a lecture for x amount of time, and usually it was, at minimal, for fifteen minute lecture” (Pre-observation Interview). As a result of her past experiences, Mary believed teaching science revolved around delivering terms and concepts to students. She expressed this view a number of times—in talking about views of the teacher and student roles, her goals for teaching science, and in how she planned to teach. Mary expected that, as a teacher, she would be the leader in the classroom. Being a leader meant she was responsible for content, pace, and linking the big ideas
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Together through teacher-centered strategies, such as lectures. Mary believed teachers “can’t wait for every student to grasp the concept, they should make sure they understand at least the basics” (Pre-observation Interview). During the Entry Task Interview, Mary talked at length about her role and made few comments about the students’ responsibilities in her classroom. In accordance with her views that teachers are leaders, she believed students have a passive role.

Mary’s central goal for teaching science was to present content so students could apply science to their lives. This goal included applying science ideas to students’ current lives as well as in the future when they enter the workforce. Mary explained:

Even if they’ll never do science again, I mean, which, you know, they will, they’re in eighth grade, but even if they never do again that’s something that’s very important that they can apply to their daily life, in the business world, in college, I mean, in the work force. (Pre-observation Interview)

Mary believed when she presented new content, she could show students how new science ideas are applicable in their own lives.

End of Summer

After Educational Foundation courses and a Science Methods course, Mary continued to view teaching as telling students science terms and concepts and learning as listening to teachers’ explanations. Her views of the teacher’s roles had not changed significantly. In describing her views of teacher and student roles, Mary believed she should be the leader in the class and focused on transmitting knowledge through lectures. She said, “I'm most comfortable with lectures because when they come back here you may lose control of them” (End of Summer Interview). Mary still thought her students had a passive role in learning. She said, “The students’ role is to learn and in some sense shut up, sit down, and write down information” (End of Summer Interview). Mary described her central goal as presenting science content. She planned to use students’ life experiences as a bridge for introducing new content. Her goal was to “focus in on what do we know, let’s go from there, and that can kind of get students more involved also” (End of Summer Interview).

Internship Context

During Mary’s internship, she worked in a human anatomy class. Her mentor, Melanie, had taught anatomy for 6 years and was working on her Masters degree in Education. Mary talked about her internship with Melanie and how she was learning to teach by observing, mimicking, and coteaching. Mary explained, “She (referring to mentor) will teach on A Days then I will see how she presents the materials and I will relearn it. Then on B Days I’ll present” (Pre-observation Interview). When Mary designed her own activities during the semester, she used the human anatomy objectives and common assessments.

Mentor Teacher’s Science Teaching Orientation

The mentor teacher, Melanie, held an orientation to science teaching that was largely based on her view that teaching is telling and learning is listening. She expressed this number of times when talking about her views of the teacher and student roles. Melanie thought teachers need to be leaders; meaning that in human anatomy, teachers are responsible for using lectures to teach students new terms and concepts. She said, “We have objectives and key terms to give to the student.” Melanie talked about the students’ role in human anatomy when describing what
she wanted them to understand about the heart. Melanie commented, “There are times when we have so much stray content in our class. They (referring to the students) do need to stop and go, “ok, I (referring to the students) know these four parts of the heart and I can point to where they are, and ok I’m good.” Thus, Melanie believed that students have mostly a passive role in learning anatomy and are responsible for knowing the terms that the teacher or textbook provides. Melanie’s goals and purposes for teaching human anatomy were related to her views of teaching and learning. She focused on covering content addressed in her school’s science curriculum guide and the state standards in order to prepare students for future high school courses and college. She said, “For most of our kids they’re going away to college, and we’re sort of preparing them to feel comfortable in a science class that has a lot of big words. Thus Melanie’s orientation to science teaching was mostly a didactic view in which teachers transmit content to students through lectures.

Fall and Spring Semesters

The nature of the internship context strongly reinforced Mary’s science teaching orientation, which focused on delivering vocabulary to students. When asked whether lectures were her preferred mode of instruction, Mary remarked, “I guess for me there's a difference between preferred and comfortable, it is the most comfortable for me … since it's what I was raised on.” (Fall Interview) For Mary, lecturing is a comfortable strategy to teach science and primarily used in her teaching context. Mary learned that, in addition to giving students notes, teachers have other responsibilities. She explained:

I would have said the teacher's role is to give all the information and now it's clear that the teacher clears up misconceptions, is responsible for the information, for the learning, and testing them and assessing if they learned. (Fall Interview)

Mary believed teachers should provide knowledge, resolve student misconceptions, and assess student knowledge. She thought students have a passive role in the class and are responsible for following her lead. In accordance with these views, Mary believed the goal of science teaching was to present content.

The Development of Mary’s Orientation to Science Teaching

Mary came into the APB program with the belief that teaching is telling and learning is listening. Mary’s experiences in the APB courses provided her with knowledge of student-centered orientations. Even though she learned about other strategies and sequences in the Secondary Science Methods courses, Mary preferred didactic forms of instruction. The APB course work was very different from her own experiences as a student. Mary said she was “raised on the teaching style, unfortunately, where the teacher just kind of takes over” (End of Summer Interview). She believed the instructors in the summer courses were not supportive of lecturing. Based on her own college science learning experiences, it was difficult for Mary to consider other types of instruction. She said, “Five years of college, it’s all been lecture-based” (End of Summer Interview). Mary’s orientation of teaching is telling and learning is listening was strongly reinforced by her internship context where teacher-centered, traditional-transmission modes of instruction were the norm. Although Mary’s added goals during the APB program, her science teaching orientation did not change significantly (see Table 4).

[Insert Table 4 about here]
Experiences Prior to Program

Amy, age 26, graduated with an undergraduate degree in biology and planned to pursue a medical degree. After completing an internship in a hospital, she decided against attending medical school because “the lifestyle of a doctor wasn’t the lifestyle [she] wanted to live.” In Amy’s application materials she described her reasons for changing career paths: “Being a teacher would allow me to give back to society in a positive and rewarding way, while still leaving time for my family and other things in life that I find important.”

Amy had numerous informal experiences working with youth as a snowboard instructor, soccer coach, and camp counselor. She wrote at length in her application materials about how she worked closely with adolescents and developed different programs in these contexts to pique students’ interests. Amy also worked in a formal K-12 setting as a substitute teacher. However, she believed her job as a substitute teacher provided her with limited opportunities to plan and teach science content. When Amy described her job as a substitute she said the regular classroom teachers “would give us all the information that they wanted to give.” Additionally, most of her substitute teaching experiences were in elementary classrooms where she “did a lot of babysitting.”

Entry

Based on Amy’s experience as a mentor and a K-16 student, she thought the teacher’s role was to be a leader. Amy emphasized the importance of connecting new content to students’ experiences through teacher-led discussions. She planned to discuss family trees because “it might make it easier [to see the] association of the different traits with the different family members” (Entry Task Interview). Additionally, Amy would highlight important content by leading students during discussions. She mentioned, “While they’re discussing I’ll make notes on the overhead” (Entry Task Interview). Amy focused on the teachers’ role and believed students are responsible for following the teacher’s lead.

Amy’s central goals for teaching science included the following: for students to apply science to their lives, and to prepare students for future science courses. She explained, “I want my students to not only learn the subject material, but also take away valuable life learning lessons. I want them to learn to think analytically and critically not only in the classroom, but also in their everyday lives” (Video Task). Amy also talked about the importance of preparing students for future courses. She wrote, “I would be satisfied if I was able to cover all of the material on the lesson plan for the day and had time for discussion at the end” (Video Reflection). Amy believed she needed to cover the content so students were prepared for high school science courses.

End of Summer

After 11 weeks of APB coursework, Amy continued to view science teaching as telling and learning as listening. Amy reported it was her responsibility to start off leading the discussion by presenting terms and concepts, and then provide students with some freedom to work with new ideas by talking with their peers so they feel a sense of ownership for learning. Amy described her role as a leader,
Developing Orientations

I would kind of start off initially leading class discussion and then let the kids go on and I’d just walk around and listen and ask questions and kind of pipe in every once in a while. So, they’re feeling like they have control of what they’re talking about. (End of Summer Interview)

Although Amy learned about student-centered activities from the Science Methods course, her beliefs about teaching remained teacher-centered. During the end of the summer interview, Amy focused on her responsibilities during the lesson and still believed students have a passive role and are responsible for following the teacher’s lead.

Amy’s central goal for teaching science continued to be to present science content so students could apply their science knowledge to their lives. In her lessons on heredity, she wanted students to think deeply about variation found in nature. She stated:

It’s not just within humans, but that there’s a reason why everything’s different. There’s a reason why in Missouri we don’t have palm trees and in Florida they do. And just that … that there is genetic variation or whatever within such a large species, that’s the reason why. (End of Summer Interview)

Amy still held a central goal of preparing students for future science classes. She said, “Just to give them kind of a solid framework to work with whenever they are taking a genetics course later in high school or in college. They can look back and go, oh, I remember” (End of Summer Interview). Amy believed one reason students learn science in 8th grade is to prepare for high school science courses.

Internship Context

For the 2006-2007 school year, Amy was placed in an internship with an experienced mentor, Irene, at Rover High School. Irene was a veteran teacher (25+ years) with National Board certification. As the chair of the science department, Irene believed teachers who taught the same courses should meet frequently to design a common curriculum that included: lessons, assessments, and unit objectives supported by state and national standards. Interns were encouraged to participate in weekly science faculty meetings and contribute teaching ideas for meeting the unit objectives. Amy took part in the weekly biology group meetings and described them by saying “we try to do it exactly the same as the other honors biology. So the beginning of the week before each new unit, we all get together and kind of go over what we’re doing” (Pre-observation Interview).

Irene believed interns needed to observe and mimic experienced mentors. While students mimicked her teaching style, Irene co-taught with them so she could add her science knowledge and experiences during the lessons. Irene believed coteaching helped interns learn about instructional pace and timing, and ensured the interns kept the same pace with other biology classes. As interns gained experience, Irene allowed them to use the unit objectives and common assessments to design some of their own instructional activities. After interns gained experience, Irene still used a coteaching approach, but did not have students observe and mimic her style. Amy described her experiences as an intern, “I have not done a lot of the actual planning … I probably teach at least half of every hour. Some days I teach the whole hour, but Irene and I generally coteach things together” (Pre-observation Interview). When Amy created her own notes and quizzes she talked about using her mentor’s lectures as a guide: “I usually generally take her notes … and make up my own notes based on that. It’s not starting from scratch by any means” (Pre-observation Interview).
**Mentor Teacher’s Science Teaching Orientation**

Irene’s view of teaching and learning focused on setting and meeting objectives. She said, “we have pretty high expectations in our Biology classes for example that yes, this is the level they will learn, this is the amount they will learn, these are the kinds of experiences they will have.” For Irene, teaching is more than telling. Teachers need to provide lots of opportunities for students to practice new information. The teacher’s role is to select the objectives for the lesson and to design activities that will help students meet the objectives. The activities might include lectures, labs, stations, and class discussions. It’s the teacher’s job to informally assess student learning and to provide opportunities for students to assess their own progress toward meeting the objectives. It is also the teacher’s job to provide standards to illustrate what it means to meet a specific objective. The students’ role is to do what the teacher asks. She thought that when students are actively engaged and asking lots of questions they learn science better. Additionally, she likes days when labs don’t work. She said, “I love to do a lab and it isn’t working and I don’t know why because then we all have to figure it out.”

Irene was able to easily express her overall goals and purposes for teaching high school biology. She explained, “My job is help you be smarter.” When probed to define what this meant, she referred to Bloom’s Taxonomy. She wants students to be able to analyze, evaluate, and synthesis new information. She wants students to have the skills so that “when they have a situation, they can say, oh, what should I do here?” Irene stated that she wanted students to “have some sense of the world around you.” She wanted her students to become educated adults so that they could be good citizens. She also wanted to prepare them to take future biology courses.

**Fall and Spring Semester**

Amy retained the view that science teaching is telling and learning is listening. She explained, “The role of the teacher was to provide guidance for the daily class activities and to make sure the students are staying on task. You are giving them the materials that they need in order to understand the objective” (Fall Interview). Amy was working on becoming more assertive and directive with students. Amy commented, “One of the main things we’ve been working on is, just being more drill sergeant-like, telling students pick up your piece of paper, write these three things down, do this” (Fall Interview). Accordingly, the students’ role was to follow the teacher’s lead. She explained:

- The student’s role is to … do what we’re asking them to do and be a student …
- The role of the student is to come to school and be prepared for whatever, and the teacher needs to be prepared to do. The student needs to be prepared to learn and turn in their homework assignments, those kinds of things and just to learn.

(Spring Interview)

According to these views, Amy believed the central goal of science teaching was to present science terms and concepts to students. She explained:

- Most of this biology stuff is kind of new to them so I feel like we have to start from the beginning, like this is what DNA is because they don’t have any previous knowledge on that. But once we start giving them information, they pick it up really quickly and they’re able to apply new knowledge to the old knowledge. (Fall Interview)

Amy focused on the importance of presenting content to students because she thought the biology content was new to students.
During the fall semester, because of the unit she was teaching, Amy’s goals changed and she focused on presenting content so students were ready to make scientifically-based decisions. She thought science class was a place for students to receive accurate information about different types of cloning such as therapeutic and reproductive cloning. According to Amy,

I want them to realize that that’s not the only kind of cloning [referring to reproductive cloning] that, there are variants to that. Just to give them a broader understanding of something that they obviously have heard about, with the elections that were just a few months ago, so they’ve known something about it and have heard something about it. (Fall Interview)

Amy talked about students needing to be informed because the media’s portrayal of cloning is not always scientifically accurate.

**Development of Amy’s Science Teaching Orientation**

Amy entered the APB program believing science teaching is telling and learning is listening based on her observations of science teachers who primarily used delivery modes of instruction. This view was strongly reinforced in her internship where she observed, mimicked, and taught using primarily teacher-centered practices. Amy believed that Irene’s mentoring was vital for her professional growth as a teacher and without the mentoring she believed, “I wouldn’t be able to do it at all I don’t think. I wouldn’t be comfortable as a first year teacher (Spring Interview). Amy reflected on how the APB coursework influenced her beliefs about science teaching. Amy thought the Secondary Science Methods course instructors focused on only inquiry-based teaching strategies. She said, “I feel like in school [referring to the Secondary Science Methods courses] they don’t always give you that other way. It’s always inquiry based” (Spring Interview). Even though she learned new instructional strategies, like the 5E instructional model, and how this sequence relates to student learning, she reflected exclusively on the internship when speaking about how she has learned to teach. She explained in detail:

I think that the courses at the university you learn all of these things, you learn about classroom management, you learn about the different teaching philosophies in Educational Psychology and all of that kind of stuff. You learn about this 5E instructional model, and so I have it all there but I don’t really use it … So, I think the most beneficial thing for me was my student teaching and working with my mentor teacher where I can say, when she gives me a whole unit to do, I can try to use all of that stuff that I’ve learned and implement it with her advisory and her saying ‘oh, no we’ve tried this before. This is going to work.’ (Spring Interview)

Although Amy added additional goals during the fall and spring semesters, there is little evidence that she held other orientations to science teaching during nine months of the APB program. Over time, Amy’s science teaching orientation was highly resistant to change and remained stable over time (see Table 5).

[Insert Table 5 about here]
Lilly’s Case

Experiences Prior to Program

Lilly, age 23, began her academic career in journalism, switching to biology after four semesters. In the fall of her freshman year, she enrolled in a general biology that led her to switch to a biology major. She stated, “The professor’s enthusiasm for the subject helped me realize my own interest in biology, leading me to change my major.” Not only did her professor influence her interests in biology, but she had an impact on her desire to become a science teacher. Lilly said, “The impact this professor had on my choice of major helped me recognize the great effect teachers can have on students and fostered my desire to teach biology.” After Lilly completed an undergraduate degree in biology from a large research extensive institution she entered the APB program.

Entry

Lilly’s images of teaching and learning were based on memories of her teachers who taught using traditional, transmission modes of teaching. As a result, Lilly believed science teaching is telling and learning is listening. She expressed this view a number of times, in her comments about the teacher and student roles, her goals, and how she planned to teach. Lilly explained that her role in the science class is to be a leader and students should take vocabulary notes, practice terms and concepts, and ask questions when they are confused. Lilly focused on her responsibilities during instruction, and believed that students have a passive role in the classroom.

Lilly’s views about the teacher and student roles were related to her central goal for teaching science, which was to prepare and motivate students for future science courses. She commented:

Before going into high school, where they’re going to have a little bit more advanced biology, I think that understanding these basic topics … gets them more interest in the topic, in the subject, so they would actually be interested in learning once they get on to the higher levels (Entry Task Interview).

Lilly talked at length about students needing to understand basic concepts in middle school in order to motivate and prepare them for high school science courses. Lilly’s memories of how her teachers taught influenced her science teaching orientation.

End of Summer

While Lilly talked about a number of reasons for teaching science in middle school, she retained her image that teaching is telling and learning is listening. She continued to describe the teacher’s role as the leader who controls the content in the classroom. As a leader, Lilly acknowledged she must “maintain the fact that you are the one who’s in charge. (End of Summer Interview)” Lilly believed students are responsible for following the teacher’s lead. Lilly also kept her central goal, which was to prepare students for future science-related courses. She talked about “getting as much knowledge to them as possible while still staying somewhat on track, so they’ll be ready for the next year” (End of Summer Interview). Lilly saw middle school as an opportunity to provide students with prerequisite factual science knowledge in preparation for high school science courses.
Developing Orientations

Lilly developed additional views of the teacher’s role based on her experiences in the Secondary Science Methods courses. For example, she thought that it was her responsibility to act as a guide. Guides allow students some freedom in choosing the content they want to study. Lilly said, “Guiding them, I mean you want to let the kids pick what they can do to an extent, giving them ideas kind of and setting certain parameters” (End of Summer Interview). Additionally, Lilly wanted students to have fun in science class. Lilly thought that letting students choose the content they wanted to study would be a way for students to have fun while learning science. She stated, “I think it’s a lot more fun if the kids get to pick what they do because they actually want to do it then, which is the whole goal. (End of Summer Interview)”

Internship Context

During the 2006-2007 school year, Lilly worked with an experienced mentor, Linda, at Monroe High School. Linda had mentored numerous student teachers over the years and provided resources and curriculum materials including lecture notes, assessments, and laboratories. In the beginning of the school year, Linda asked her interns to watching her teach. Then, interns mimicked her style in subsequent class periods. Once interns were comfortable teaching, they designed lessons using Linda’s resources. During this time, Linda expected to see daily lesson plans and provided interns with detailed and frequent feedback. Linda allowed interns to use her curriculum, but encouraged them to find new and different activities from the ones she provided. With time, she expected interns to prepare lessons for two different class periods.

Mentor Teacher’s Science Teaching Orientation

Linda’s orientation to science teaching was based on the view that teaching is telling and learning is practicing new terms and concepts. Linda thought that teachers are responsible for “explaining the information” and if teachers provide multiple exposures to new content than students will learn science. She said, “for many of the students you have to teach and re-teach a concept. And not do it in the same way but come back at it a different way.” Providing multiple opportunities for students to practice new terms and concepts helps them commit science content to memory. Linda provided students with multiple exposures to new content by bringing in “resources” and “hands-on activities.”

Linda’s goals were related to her views of teaching and learning. Linda’s goal for teaching science was to cover a breadth of science curriculum in the state standards in order to prepare students for state mandated tests. Linda said, “We have always been about preparing the kids for the standardized test at the state level and we will again this year and last year with the MAP (referring to the state mandated test). The GLE’s (referring to the state standards) are a big component.” Linda had a second goal that motivated her use of hands-on activities, “I truly want them to enjoy science. I hear a lot of students that come to me and there first word out of their mouth is math, and I hate science, or this (referring to science) is not important. I want them to enjoy the class.” Thus, Linda’s science teaching orientation mostly focused on the view that teaching is telling and she hoped students would have fun doing the multiple activities she had planned to help them learn science.
After teaching with Linda for approximately nine months, Lilly’s orientation had not changed significantly. She continued to believe science teaching is mostly telling and learning is listening. Lilly viewed teachers as both guides and leaders. She said, “I guess guiding them through the lesson, and they obviously don’t have control, I do, giving them material but not just directing the whole time because they are involved as well” (Fall Interview). Lilly believed her lessons varied from being teacher-guided to student-led. According to Lilly, If it is more of going over new material, it’s really guiding them through the new material and being sort of in command of what is going on. With a lesson like today, it’s more students working on their own with the lab (Fall Interview).

When talking about the students’ role in the science class, Lilly thought students should focus on the content and on “being a student,” meaning that students work on science when in science class (Fall Interview). The students’ role included participating in class discussion, writing notes and asking questions when confused. Lilly explained in detail:

A student’s job is to be working on whatever the activity is, if that means they’re all caught up maybe helping their neighbor with what they are working on. A lot of times they want to get out other homework from other classes and work on it. I think that one of their jobs is to stay in the lesson and stay with it even if some students work so much faster than others and I know they get bored and we have to wait for everyone. (Spring Interview)

Regardless of the pace at which students finished their tasks, Lilly believed they should always be engaged in science when in science class. Lilly’s central goal in science teaching was to present science content so students could apply science to their lives. She stated, “I want them to think what we are doing is interesting and make it feel relevant to them” (Fall Interview).

Lilly realized there were differences between what she has learned in the Secondary Science Methods courses about inquiry and her experiences teaching in her internship. She spoke about these differences in detail. She learned that many students do like the responsibility of learning science on their own and engaging in inquiry investigations. Lilly explained,
It [inquiry] just gives the students a lot of freedom as far as what they’re investigating; what kind of data or observations they should make; choosing, there’s a lot of, like, choice involved, which is great, but I don’t think a lot of students like that … In my opinion, doing full open inquiry is impossible in high school, and maybe that’s not fair for me to say. Maybe some people can. For me, though, it just doesn’t work because it’s way too much, putting way too much responsibility in the student’s hands, and I don’t think they even like it. (Spring Interview)

The strategies she learned about in the Secondary Science Methods course contrasted with her experiences in the internship. Although she developed additional goals and views of the teacher’s role her science teaching orientation remained consistent throughout the program (see Table 6).

[Insert Table 6 about here]

Jason’s Case

Experiences Prior to Program

Jason, age 24, graduated with a biology degree from a large research extensive institution located in the Midwest. During his undergraduate studies he worked with high school students as a leader in Young Life, a Christian youth organization. In this role, Jason led discussions, acted as a tutor, and mentored students regarding personal choices in their lives. He talked at length about his background experiences in Young Life where he wanted to help students mature into responsible citizens and believed he could engage adolescents in discussions about real-world problems. Additionally, Jason believed it was through discussions in Young Life that many adolescents discovered themselves by gaining an understanding of how spirituality helps them make sense of their world. Jason entered the APB program directly after completion of his undergraduate degree.

Entry

Jason’s views of teaching were based on his prior experiences. Through Young Life, Jason had success leading discussions to help students discover knowledge on their own. He commented:

In my experiences with Young Life, I like to ask kids questions. It gets kids involved. I have definitely learned not to ask yes or no questions. Starting every day with questions gets them warmed up. You don’t just jump in and start lecturing because kids … are leaving English class and entering Science class kind of thing and I think it just gets more kids involved you know when you are just asking them. (Entry Task Interview)

As a K-16 student, Jason observed teachers primarily using delivery modes of instruction. Jason believed teaching revolved around using teacher-led discussions to introduce concepts so students could eventually discover science knowledge. He articulated this belief a number of times, in speaking about his views of the teacher and student roles, his views of the nature of science, his goals for science teaching, and how he planned to teach. Jason viewed teachers as guides and he “didn’t just want to lecture to kids” (Entry Task Interview). He wanted to “lead students in such a way that they are discovering things on their own” (Video Reflection). Jason
realized that, in science classrooms, science is an independent activity as opposed to authentic science which is a social endeavor. Jason viewed science as a way to socially create knowledge. He described his view of the nature of science in detail:

I think in high school you … study for your test, do your own worksheet, and your own homework. But like once you get to college, and then even in the real world, science isn’t like that at all. You collaborate, you use other people’s information to go further and stuff. So I think that it would be good to explain like real science is when you get together and work together and use each other’s ideas and stuff. So it would be building … the bigger picture of what science is…. It is not just memorizing facts. It’s kind of like using each other to figure stuff out. (Entry Task Interview)

Jason’s central goal was to develop students’ understanding of science so they could apply science ideas to their everyday lives. Jason’s other central goal for teaching science was to prepare students for future science courses. He explained that heritable variation is “a big chunk of like what everything is built on” and thought “there are a few pieces of like just basic science that are needed. I think it is just one of the cores” (Entry Task Interview). Jason’s science teaching orientation embodied both a social and practical undertaking and his mission in science teaching was closely linked to his work in Young Life.

End of the Summer

Jason continued to believe he could expose students to important ideas through teacher-led discussions to help students discover science concepts on their own. Jason said, “I would rather have them talk more, then I would just get them involved and see what they think and then trying to get them to lead their own thinking” (End of Summer Interview). To address students’ needs, he would need to guide students and use teacher-led discussions to help students become more self-directed learners. He explained, “If you lead them … giving them more control step by step, it would be a lot better, less frustrating than just throwing them into it” (End of the Summer Interview).

Jason believed his views of the students’ role in the classroom changed since the beginning of the summer as a result of the APB courses. He stated, “I think the whole teacher-center versus student-center thing is changing for me. Letting them lead more of the curriculum instead of the teacher just guiding it every day” (End of the Summer Interview). The Science Methods course provided opportunities for reflection. Many of Jason’s K-12 science experiences were teacher-centered and traditional in nature. He commented:

I really loved the idea of letting the students taking control of more of their own learning. It was really cool to see that and the whole idea of making science more realistic, because I know in my biology experience in high school it was more of just the study of biological facts, not really studying biology. It’s cool to see you can make it more realistic and stuff, and that was pretty exciting. (End of the Summer Interview)

Jason believed that if he were to provide more student-centered learning experiences, he would need to have a more robust knowledge of the subject matter. He commented, “It made me realize that if I really want to implement more of the student-centered thing, I am going to need to know my content area a lot more than just superficial talk” (End of the Summer Interview).
Developing Orientations

Jason’s central goal was still to provide opportunities for students to be able to “lead their own thinking,” and “figure it out on their own,” because he thought science provided a way for students to discover knowledge (End of the Summer Interview).

Internship Context

For the 2006-2007 school year, Jason was assigned to an experienced mentor, Nancy, at Harris High School. Nancy had hosted student teachers in the past and provided them curriculum materials including unit objectives, common assessments, and packets containing all the student worksheets for a unit. The biology teachers at Harris High school used the same instructional materials and met frequently to design curriculum. Jason described how he used the common curriculum and how Nancy mentored him,

She gives me all of her stuff and she tells me … you need to cover these [referring to objectives] you know, and she basically lets me do my own thing . . . And we talk a lot so she knows what is going on . . . (Fall Interview)

Unlike other APB interns, Jason taught a complete teaching load during the spring semester because Nancy was on maternity leave for three months. The other teachers in the high school biology department supported Jason and provided resources and materials.

Mentor Teacher’s Science Teaching Orientation

Nancy believed teaching is telling and learning is listening she expressed this view a number of times. When talking about the teacher’s role and student roles she said, “I’m the alpha here and this is how things are going to run and we are going to get along find.” She teachers are responsible for delivering content through “structured lecture or reading assignments.” Additionally she thought that teacher’s need to, “sometimes cut to the chase and deliver information.” According to her views of the teacher’s role, Nancy thought students are responsible for following the teachers’ lead. She focused on students learning from the teacher telling versus students learning from firsthand experiences in science. She said, “You get really optimistic about what kids are getting from your teaching and it’s really disappointing when wow they can’t put that together at all.”

Nancy’s goals were related to her views of teaching and learning. She wanted to present content addressed in the school and state standards so students would be prepared for future science courses. She said, “The district has a curriculum and we have to meet state standards and grade expectations and there are certain things that kids are suppose to know by the time they leave biology class.” Related to this goal, she thought students needed background knowledge like terms and concepts before they could explore biological phenomenon through hands-on investigations. She explained the importance of terms and concepts in biology in relation to the nature of science:

You would like to think science is about learning and inquiring knowledge through experimentation, through observation, through the scientific method basically. But if you don’t have any background or any tools- you don’t really know where to start. So we are at the level were providing the background so hopefully some of them may do some of that research and original work.

In summary, Nancy viewed teaching and learning as a one-way process where the teacher transmits new biology terms and concepts to students who are responsible for understanding and applying these ideas in her course, future courses, and their daily lives.
Developing Orientations

**Fall /Spring Semester**

During the fall and spring semesters, Jason continued to view teaching as a process of discovering knowledge through teacher-led discussions. He believed he could facilitate students’ understanding of science content by guiding them. He described his preferred teaching style by saying, “I don’t want my style to be just presenting information … I would like my style to be more cooperation, just kind of like back and forth. Seeing, if we need to go back and learn more” (Fall Interview). Jason explained how he favored active teaching practices that encouraged student participation. He commented, “I want these kids to get up front and teach instead of me just lecturing them” (Fall Interview). Additionally Jason thought students should lead their own learning by asking questions. He explained, “I think their role would be to ask the questions to learn and to understand the stuff, by doing stuff, or asking questions” (Fall Interview). Jason believed it was important for him to provide a student-centered environment where students have an active role and collaborate to discover knowledge.

Jason also retained his central goal that students should be able to apply science to their everyday lives to discover science concepts on their own. He explained:

> My objective for them just to be able to take it to the next level not just take what someone says to them is the answer. Give them the opportunity to predict, observe, and explain and just to give them the opportunity to see that this is real scientific method and give them the tools so they can do this in the future. (Spring Interview)

Jason added a goal for teaching science as a result of his teaching context. He added a peripheral goal of presenting science vocabulary; this meant that he needed to provide students with new terminology and concepts through lectures and teacher-led discussions. Jason talked about wanting student to learn the “main functions of each organelle,” and to “understand the difference between a plant and animal cell,” because they were part of Harris High School’s biology objectives (Fall Interview). Although Jason gained a peripheral goal, his science teaching orientation had not changed significantly.

**Development of Jason’s Orientation to Science Teaching**

Jason held competing views of teaching and learning. Ideally, based on his Young Life experiences, he wanted students to discover science on their own through. He consistently saw his teaching as a two-way process of communicating through teacher-led discussions. When Jason talked about teaching student he said, “I want it to be more of an interaction. I don’t want it to be, okay I’ve done my duty, now it’s on their end (Spring Interview)” Although Jason took on additional goals from working with his mentor teacher, his teaching orientation remained resistant to change (see Table 6).

[Insert Table 6 about here]

**Assertions: Prospective Secondary Teachers’ Science Teaching Orientations**

Based on cross-case analysis, we generated assertions describing the major themes common among our participants’ science teaching orientations. Our participants formed their science teaching orientations based on their K-16 learning experiences and additional background experiences; their science teaching orientations were robust and resistant to change. The mentor teachers re-enforced dimensions of the prospective teachers’ incoming science
Developing Orientations

All four teachers held teaching orientations shaped by their background experiences as K-16 students and youth mentors. Mary, Amy, and Lilly entered the APB program with science teaching orientations primarily influenced by their experiences as students. These three prospective teachers were highly committed to the view that science teaching is transferring knowledge to students (see Tables 4-6). Jason held an orientation to science teaching that was largely based on his experiences mentoring youth in Young Life and from his K-16 school experiences. Jason was successful using discussions in Young Life to help students discover life lessons. However, he experienced delivery modes of instruction as a K-16 student. Jason held competing conceptions based on these background experiences. Ideally, he hoped he could guide students in discovering science on their own through discussions. However, there are great differences between using discussions to discover life lessons, and using discussions in science. Scientists do not discover general principles from particular terms, concepts, or instances. Rather, scientists invent theories that are checked against observations, experiences, and empirical data. From watching his K-16 science teachers, Jason believed he needed to use teacher-led discussions to provide students with new terms and concepts. Because of his experiences in Young Life and his contrasting experiences as a student, Jason held competing conceptions of teaching and learning (see Table 7).

Although the participants gained additional goals and views of the teacher’s role, the central components of their science teaching orientations were robust and did not change significantly throughout the APB program (see Tables 4-7). Mary, Amy, and Lilly consistently believed that teaching is telling and learning is listening. These three individuals believed the teachers’ role was mostly to lead students who have a passive role (i.e., “followers”) in learning science (see Tables 4-6). Similarly, Jason’s orientation did not change significantly. During the APB program, Jason had two views of teaching and learning: (a) learning is a process of discovering knowledge so students can apply science to life, (b) teaching is providing content through teacher-led discussions and learning is participating in discussions. According to these views he believed that teachers are responsible for guiding students while the students’ role is be open-minded and inquisitive so they discover some science content on their own (see Table 7).

Assertion 2: The mentor teachers re-enforced dimensions of the prospective teachers’ incoming science teaching orientations and had the greatest influence on the elaboration of prospective teachers’ science teaching orientations. Further elaborations (i.e., additional goals and views of the teacher/student roles) were congruent with the prospective teachers’ incoming science teaching orientations.
Mary, Amy, and Lilly were assigned to work with mentor teachers who predominantly used traditional, transmission types of instruction, and the mentors strongly reinforced the prospective teachers’ incoming science teaching orientations (see Tables 4-6). These three prospective teachers gained knowledge that was congruent with dimensions of their science teaching orientation. Mary and Lilly learned from their mentor teachers and students that learners need multiple exposures to new content to memorize vocabulary. Amy learned that she needed to break-up lectures with peer teaching, which meant to her that students practice the ideas covered in lectures to help them commit vocabulary to memory. These views of the requirements for learning meshed with their views of teachers as leaders and/or guides who are responsible for transmitting knowledge to students.

Jason was also assigned to work with a mentor who primarily used teacher-centered types of instruction. During his internship, Jason developed a goal of having students learn science vocabulary. This meant that during teacher-led discussions and lectures he focused on terms and concepts that were addressed in his school’s science curriculum. The addition of this goal from working with his mentor teacher aligned with his belief that students need teacher-led discussions (see Table 7). Due to the nature of his mentor teacher’s instructional practices, Jason did not replace his ideas about discovery learning and discussions with more accurate conceptions of how science knowledge is invented rather than discovered. As a result, his conflict of using teacher-centered discussions persisted throughout the ABP program.

In summary, certain dimensions of the prospective teachers’ incoming science teaching orientations were strongly reinforced by their mentor teachers. The four mentor teachers in this study primarily implemented traditional, teacher-centered instructional approaches.

Assertion 3: Prospective teachers’ science teaching orientations acted as filters for making sense of experiences during the APB program.

During the nine months of the APB internship, the prospective teachers interpreted experiences based on their science teaching orientation. For example, as a result of the Secondary Science Methods courses, Mary’s view of teaching and learning expanded to include building on students’ prior science knowledge. This meant that Mary began lectures with content that was familiar to her students. Amy’s goals expanded to include preparing students to make educated decisions due to the cloning unit she was teaching in the fall semester. She led discussions with students about the positive and negative aspects of therapeutic and reproductive cloning. After the first summer in the APB program, Lilly thought that teachers let students have some choices when deciding what content to study. In the fall, Lilly let students manipulate variables in a laboratory after she had lectured to them on diffusion and osmosis, had a similar laboratory experiences, and practiced new terms and concepts through worksheets. Even though these teachers added goals for teaching science to their orientations, their views that teaching and learning is mostly a teacher-centered process that is facilitated through lectures and teacher-led discussions persisted for throughout nine months in the APB program. The prospective teachers’ additional goals and views of the teacher/student role were congruent with their views that teaching is telling and learning is listening. Mary, Amy, and Lilly’s science teaching orientations acted as a barrier to developing more sophisticated PCK. Amy, Mary, and Lilly never became dissatisfied with their view of teaching is telling and learning is listening. As a result, these three teachers struggled to embrace reform-oriented views of teaching and learning.
because these views deviated from their science teaching orientations and their experiences working with their mentors.

Jason’s orientation also acted as a filter for making sense of his experiences in the APB program. He drew on multiple experiences during the APB program to try and resolve tensions in his views of teaching and learning. Jason drew on his Young Life experiences because he was dissatisfied with his K-16 experiences that were mostly traditional and teacher-centered in nature. He was eager to find new ways to think about science teaching that mirrored his knowledge of learners from Young Life. As a result, he embraced some of the strategies presented in the Science Methods courses because they provided intelligible ways to make teaching and learning more student-centered. For example, he tried to sequence science instruction in a 5E during the spring semester. Although he had students make scientific claims based on evidence during his 5E unit on cells, he thought he needed to begin the lesson with a lecture over cellular structure and function. Thus, his view that teaching and learning is primarily facilitated through teacher-led discussions influenced his knowledge of sequencing science instruction through the 5Es.

Jason entered the APB program with more student-centered views of teaching than the other three participants. Jason’s conflict was a result of the interaction taking place between different views of teaching and learning. At the end of nine months in the APB program, Jason was in the process of restructuring his knowledge of teaching and learning. Implementing the 5E instructional model and replacing views of discovery learning may require a more radical re-structuring of Jason’s science teaching orientation. Ultimately, Jason was unable to completely abandon his beliefs about using traditional instructional strategies focused on explaining content to students.

Discussion

The purpose of this study was to investigate the nature and development of prospective teachers’ orientations to science teaching. To aid in this task, we expanded the definition of science teaching orientations beyond beliefs about the purpose and goals for teaching a particular subject matter to also include the following dimensions: views of teaching and learning, and views of the teacher and student roles. Although each prospective teacher added to their goals and/or views of the teacher’s role, their incoming science teaching orientations were highly resistant to change. Second, these prospective teachers’ science teaching orientations were strongly reinforced by their mentor teachers who primarily used traditional, teacher-centered instructional strategies. Third, prospective teachers’ science teaching orientations acted as a filter for making sense of experiences during the APB program. Three individuals (Mary, Amy, and Lilly) struggled to embrace the student-centered, reform-oriented instructional strategies taught in the Secondary Science Methods courses that were incongruent with their science teaching orientations and their mentor teachers’ practice. Meanwhile, the other prospective teacher (Jason) in this study drew on both his mentor teacher and the science methods courses to reconcile his competing views that included teacher and student-centered aspects of teaching and learning.

Research indicates that K-16 experiences play a powerful role in the development of beginning teachers’ knowledge and beliefs about the purposes and goals for teaching (Koballa et al., 2005; Lortie, 1975). Mary, Amy, and Lilly, and Jason experienced mostly traditional, teacher-centered instruction during their K-16 education. The prospective teachers were successful graduates of traditionally taught K-16 programs, and this success provided strong
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evidence for their knowledge of teaching and learning. Their science teaching orientations were dominated by the view that teaching is telling and learning is listening. This study adds to the literature, confirming the role of K-16 education experiences in developing prospective teacher’s science teaching orientations.

Although these four individuals drew heavily on their K-16 experiences when talking about the sources of their views of teaching and learning, Jason’s case adds to the literature on how background experiences mentoring and working with youth in non-school settings influence science teaching orientations. Jason aspired to help students discover knowledge on their own based on his experiences using “open discussions” with adolescents in Young Life. Thus, Jason formed two views of teaching and learning. Ideally, he hoped students could discover science knowledge based on his experiences in Young Life. Based on his K-16 experiences, he thought he would need to use teacher-led discussions to provide content. For Jason, his knowledge of learners and the challenges of teaching led to competing views of teaching and learning.

We found that these prospective teachers’ science teaching orientations were robust. Studies report that beginning teachers’ beliefs about teaching and learning are strongly held and resistant to change (Anderson et al., 2000; Koballa et al., 2005). One interesting finding of Anderson et al. (2000) study was that elementary teachers came into their teacher preparation program already moving along a particular trajectory. These teachers valued experiences that aligned with their conceptions of teaching and learning. It seems that Mary, Amy, Lilly, and Jason also actively looked for experiences in their internship that confirmed rather than disconfirmed their existing views of teaching and learning. For example, Mary, Amy, and Lilly took on additional teacher-centered goals or views of the teacher’s role that aligned with their incoming teacher-centered science teaching orientations. Jason’s incoming view of teaching was also difficult to change because it was deeply rooted in his K-16 and Young Life experiences. Jason also took on an additional teacher-centered goal (i.e., present science terms and concepts) that aligned with a teacher-centered aspect of his science teaching orientation (present content through teacher-led discussions). Jason had limited knowledge and experiences with learning and teaching science according to his ideal view of teaching, which was for students to discover science knowledge on their own. Ultimately, Jason did not replace his ideas about “discovery learning” with current accepted conceptions of how science knowledge is “constructed” rather than “discovered.”

This study contributes to the literature by adding empirical evidence of the significant role mentor teachers play in the development of their interns’ science teaching orientations. A number of researchers have found that the nature of the internship can override prospective and beginning teachers’ abilities to implement reform-minded practices (Adams & Krockover, 1997; Feiman-Nemser, 2001; Hewson et al., 1999; Marion, Hewson, Tabachnick, & Blomker, 1999; Puk & Haines, 1999). The four mentor teachers did not use student-centered practices, nor did they encourage their interns to use the reform-orientated practices advocated in the science methods courses. For Mary, Amy, and Lilly, considerable consistency existed among their teacher-centered science teaching orientation and their mentor teacher’s instructional practices. In fact, the mentor’s role was so influential for Mary, Amy, and Lilly, that they discounted views proposed by the Science Methods courses that did not align with their incoming science teaching orientations and mentor teachers views and practices. Jason also developed teacher-centered dimensions to his science teaching orientation (i.e., goal for presenting science terms and concepts to meet the school’s science objectives) based on his experiences teaching with his mentor. His teacher-centered goal aligned with his views of transmitting content through
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teacher-centered discussions. Thus, this study builds on previous research by clarifying the vital role mentor teachers play in the development of their prospective teachers’ science teaching orientations.

Jason’s case sheds light on the importance of investigating multiple dimensions (e.g., views of teaching and learning, views of teacher/student roles, central and peripheral goals) to better understand the factors that contribute to the development of science teaching orientations. Although Jason’s science teaching orientation remained stable over time, his case is significant and adds to what we know about the nature and complexity of science teaching orientations. Unlike Mary, Amy, and Lilly, Jason held competing views of teaching and learning at the onset of the APB program. Jason formed his ideal views of teaching and learning from his Young Life experiences, and his working views of teaching and learning from his K-16 experiences. During his internship, Jason struggled to align his ideal and working views of teaching and learning. Holding both ideal and working views, simultaneously, illustrates the complexity of Jason’s science teaching orientation. Similar to Friedrichsen’s and Dana’s (2005) research that investigated the complexity of science teaching orientations, viewing science teaching orientations as a “single, homogenous entity” (e.g., Magnusson et al., 1999) was insufficient for describing Jason’s science teaching orientation. Using a single label (e.g., didactic, discovery) would mask Jason’s competing views of teaching and learning. The discrepancies among and within dimensions of Jason’s science teaching orientation played a pivotal role in the sources he drew upon when talking about his knowledge of teaching and learning. Jason drew on multiple experiences in the APB program to better align his competing views of teaching and learning.

Friedrichsen and Dana (2001) found that using Magnusson et al.’s (1999) labels (e.g., didactic, activity driven, etc…) did not adequately describe science teaching orientations. We also found Magnusson et al.’s labels to be too confining to accurately represent teachers’ goals and purposes for teaching science. By broadening our definition of science teaching orientations to include the following dimensions: views of teaching and learning, views of the teacher and student roles, and goals, we gain a deeper understanding of how they develop over time. This study contributes to the literature by investigating subtle differences and changes in prospective teachers’ science teaching orientations. Additionally, our work provides a more thorough theoretical construct for understanding science teaching orientations. The orientations that the prospective secondary science teachers brought to teacher preparation were robust and served as filters for making sense of knowledge and experiences. They also functioned as barriers to change by limiting the ideas prospective teachers were willing to entertain. Dimensions of these prospective science teachers’ orientations were strongly reinforced by their mentor teacher. In the following section, we offer implications for teacher preparation, and future research.

Implications

Teacher Education

The findings of this study indicate that teacher educators must identify and attend to prospective teachers’ science teaching orientations. As a result of background experiences, the prospective teachers came to teacher preparation with strongly held science teaching orientations. Science teaching orientations are theorized to be important indicators of classroom practice (Grossman, 1990) and the development of PCK (Magnusson et al., 1999). Thus, teacher educators must identify science teaching orientations at the onset of a teacher preparation
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program. Teacher educators are responsible for explicitly addressing views of teaching and learning that are beneficial for their students and those views that are not conducive to effective science teaching and learning. Additionally, prospective teachers must examine their views of teaching and learning in light of reform-oriented science teaching orientations. Russell and Martin (2007) suggest that teacher preparation might be better viewed as a process of conceptual change. This means that science methods courses and field experiences would help prospective teachers become dissatisfied with traditional, teacher-centered science teaching orientations while providing intelligible, alternative science teaching orientations. Creating conditions for cognitive conflict, where the teacher educator challenges prospective science teachers to look for limitations in their views of teaching and learning, and provides thoughtful reflection on views and practice, could begin to spur reconceptualizations of how to teach according to how students learn science best.

All four of the participants relied heavily on their mentor teachers’ guidance when deciding how to teach. In fact, many of the participants viewed the guided internship as separate from what they learned in the APB science methods courses. At times, the views of the mentor teachers were in direct opposition to the reform-oriented practices proposed in the APB program. Because many APB programs require a significant amount of experience teaching with a mentor, and novice teachers lack PCK, prospective teachers are heavily influenced by their mentor teachers. As teacher educators, greater attempts must be made to ensure that mentor teachers’ practices and science teaching orientations align with the values of the Science Methods courses. For example, local teachers who are graduate students may be ideal mentor teachers because they are learning about reform-minded practices in their coursework. Over time, this may be a strategy to create a cohort of reform-minded mentor teachers. This could be a strategy to create a mentor-teacher social network where mentors can draw on each other and university faculty for support. Mentor teachers can share ideas for best practice, and university faculty can provide mentors with content and theory covered in science methods courses.

The use of experienced teachers as mentors is common in many teacher education programs. This assumes that experienced mentors will be able to provide the necessary support to novice teachers to help them become highly qualified to teach science. However, experience alone does not ensure that an experienced teacher is a good mentor. Many experienced teachers do not have the skills, experiences, or knowledge of reform-oriented practices, like inquiry (Anderson, 2002). This study confirms this finding and highlights the powerful role mentors play in the development of their interns’ science teaching orientations. In order to make sure teacher candidates are highly qualified, mentor teachers need to model appropriate practices, help plan lessons, provide support when prospective teachers teach lessons, and promote reflection on practice. In order to take on these roles, this study revealed that mentors need sustained, subject-specific professional development, and support from university faculty and from other teachers. In addition, mentors need reduced teaching loads so they can co-plan and coteach with their interns.

In addition to mentor teacher professional development, university supervisors must play a role in the development of teacher knowledge. In this study, the university supervisor was an underutilized component of the APB program. University supervisors must be trained so they can: (1) help develop mentor teachers’ skills as teacher educators, (2) promote intern teachers’ reflection on their teaching practices and student learning, (3) inform mentor teachers about content taught in science methods courses, and (4) model how to implement reform-based instructional practices in unique teaching contexts.
Investigating science teaching orientations is a challenging task. Science education researchers have not reached a consensus on which beliefs are critical in shaping teacher learning and practice. We found our interpretations of science teaching orientations limited by the Magnusson et al. (1999) definition, as have other researchers (Friedrichsen & Dana, 2005). Understanding teachers’ “beliefs about the purposes and goals for teaching science” (p. 97), was not sufficient to capture the complexity of science teaching orientations and we came to understand the teachers’ science teaching orientations by investigating a number of different dimensions that included: views of teaching and learning, views of the teacher/student roles, and goals. We believe researchers must develop more rigorous standards for investigating science teaching orientations by conducting closer analyses of the dimensions used by other researchers and those used in the present study. Based on our literature review, there are similarities and differences across the dimensions researchers choose to investigate to understand science teaching orientations. Synthesizing how researchers define and describe different dimensions would be a starting point for determining whether additional dimensions are needed to more completely understand science teaching orientations. A more coherent line must be formed in the research literature to expand our knowledge of how science teaching orientations develop and the role science teaching orientations have on the development of PCK.

Conclusions

The significance of researching science teaching orientations on the development of teacher knowledge is profound. Teacher candidates come to teacher education programs with well established orientations to science teaching that are primarily based on their K-16 experiences. Their incoming science teaching orientations significantly shape how they make sense of what they learn in methods courses and field experiences. While science teaching orientations could be a powerful support for future learning, they can also act as a barrier to the development of knowledge of teaching and learning. If initial science teaching orientations are not elicited and engaged, then prospective science teachers may fail to develop reform-oriented science teaching orientations and practice. To develop reform-minded knowledge of teaching and learning, prospective teachers must become dissatisfied with their existing science teaching orientations that are teacher-centered while simultaneously finding alternative orientations intelligible, plausible, and fruitful in science teaching. This study contributes to our understanding of how science teacher orientations develop during teacher preparation programs. Revealing and confronting science teaching orientations during the course of teacher preparation is critical to the development of teacher knowledge. Teacher preparation programs that take into account the teaching orientations of their participants may significantly impact teacher practices and student learning.
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### Table 1.

**Timeline of APB Program**

<table>
<thead>
<tr>
<th>Summer Year 1</th>
<th>Fall Year 1</th>
<th>Spring Year 1</th>
<th>Summer Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Educational Foundations of Teacher Preparation (8 credits)</td>
<td>Teaching, Learning and Research in Secondary School Science II (3 credits)</td>
<td>Teaching, Learning and Research in Secondary School Science III (3 credits)</td>
<td>Integrating Mathematics and Science Instruction (2 credits)</td>
</tr>
<tr>
<td>Teaching, Learning and Research in Secondary School Science I (3 credits)</td>
<td>Reading in the Content Areas (2 credits)</td>
<td></td>
<td>Complete Portfolio and Action Research</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 School-year internship for fall and spring semesters (20 hours per week) (8 credits)</td>
</tr>
</tbody>
</table>
### Table 2.

*Secondary Science Methods Course Goals*

<table>
<thead>
<tr>
<th>Course:</th>
<th>Goals:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Science Methods I</td>
<td>- Future science teachers will develop a deeper understanding of the nature of science; the meaning of theory, principle, and law; the tentativeness of scientific knowledge; the role of &quot;truth&quot; in science; and the nature of inquiry.</td>
</tr>
<tr>
<td>(Summer 07)</td>
<td>- Future science teachers will gain experience and develop a deeper understanding of students’ conceptions and explanations about a variety of scientific phenomenon.</td>
</tr>
<tr>
<td></td>
<td>- Future science teachers will reflect on how science teachers can model and support school science inquiry.</td>
</tr>
<tr>
<td></td>
<td>- Future science teachers will become aware of instructional models that focus on conceptual change.</td>
</tr>
<tr>
<td>Secondary Science Methods II</td>
<td>- Further deepen our understanding of how people learn through review/reflection on the first course experiences and additional readings in <em>How People Learn Science</em>.</td>
</tr>
<tr>
<td>(Fall 07)</td>
<td>- Develop a working understanding of the design and rationale of the 5E Instructional Model.</td>
</tr>
<tr>
<td></td>
<td>- Design science lessons using a variety of teaching strategies. In this class we will focus on discrepant events, inquiry labs, and interactive lectures.</td>
</tr>
<tr>
<td></td>
<td>- Do the initial planning for a curriculum unit and collect teaching resources.</td>
</tr>
<tr>
<td>Secondary Science Methods III</td>
<td>- Enhance your understanding of the nature of science and scientific inquiry through the development of model lessons.</td>
</tr>
<tr>
<td>(Spring 08)</td>
<td>- Design and use pre-instructional, formative and summative assessments to inform teaching practice at each step of an instructional sequence.</td>
</tr>
<tr>
<td></td>
<td>- Design an instructional sequence informed by current learning theory, the National Science Inquiry Standards, and the Missouri Grade Level Expectations.</td>
</tr>
</tbody>
</table>
Table 3.

**Final Coding Categories for Science Teaching Orientations**

<table>
<thead>
<tr>
<th>Codes:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources</td>
<td>What the participant identifies as the origin of his/her thinking about the</td>
</tr>
<tr>
<td></td>
<td>teacher’s role, the students’ role, and the nature of the disciplines of</td>
</tr>
<tr>
<td></td>
<td>math or science</td>
</tr>
<tr>
<td>Teacher’s Role</td>
<td>The participant’s views of his/her role in the classroom</td>
</tr>
<tr>
<td>Students’ Role</td>
<td>The participant’s views of the students’ roles in the classroom</td>
</tr>
<tr>
<td>Goals</td>
<td>The participant’s intentions, aims, and purposes related to math, science,</td>
</tr>
<tr>
<td></td>
<td>teaching, and learning</td>
</tr>
<tr>
<td>Ideal Images</td>
<td>The participant’s views of &quot;how they expect to teach&quot;</td>
</tr>
</tbody>
</table>
### Table 4.

**Development of Mary’s Orientation to Science Teaching**

<table>
<thead>
<tr>
<th>Views of teaching and learning</th>
<th>Mary’s Orientation</th>
<th>Melanie’s Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry</td>
<td>• Teaching is telling, learning is listening</td>
<td>• Teaching is telling, learning is listening</td>
</tr>
<tr>
<td>End of Summer</td>
<td>• Teaching is telling, learning is listening</td>
<td>• Teaching is telling, learning is listening</td>
</tr>
<tr>
<td>Fall /Spring</td>
<td>• Teaching is telling, learning is listening</td>
<td>• Present Content (Leader)</td>
</tr>
</tbody>
</table>

| Views of the teacher roles    | • Leader           | • Leader           | • Leader |
| Views of the students roles   | • Follower         | • Follower         | • Follower |

| Central goals                | • For students to apply science to life | • For students to apply science to life | Present content |
|                             | • Build on students’ prior knowledge |                                   | • NM |
|                             |                                   |                                   | • Covering content in school’s curriculum |
|                             |                                   |                                   | • Preparing students for college |

**Note.** NM = Not mentioned
Table 5.

**Development of Amy’s Orientation to Science Teaching**

<table>
<thead>
<tr>
<th>Dimensions:</th>
<th>Entry</th>
<th>Amy’s Orientation End of Summer</th>
<th>Fall /Spring</th>
<th>Irene’s Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Views of teaching and learning</strong></td>
<td>• Teaching is telling, learning is listening</td>
<td>• Teaching is telling, learning is listening</td>
<td></td>
<td>• Focus on setting and meeting objectives.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Teaching is telling, learning is listening</td>
<td></td>
<td>• Teaching is more than telling, teachers need to provide opportunities for students to practice the new information.</td>
</tr>
<tr>
<td><strong>Views of the teacher roles</strong></td>
<td>• Leader</td>
<td>• Leader</td>
<td>• Leader</td>
<td>• Identify the objectives and design lessons to meet those objectives (Leader)</td>
</tr>
<tr>
<td></td>
<td>• Follower</td>
<td>• Follower</td>
<td>• Follower</td>
<td>• To do whatever the teacher asks them to do (Follower)</td>
</tr>
<tr>
<td><strong>Views of the students roles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Central goals</strong></td>
<td>• For students to apply science to life</td>
<td>• For students to apply science to life</td>
<td>• NM</td>
<td>• To make students smarter</td>
</tr>
<tr>
<td></td>
<td>• Prepare students for future courses</td>
<td>• Prepare students for future courses</td>
<td>• NM</td>
<td>• To help students better understand the world around them</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Prepare students for future biology courses</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note. NM= Not mentioned</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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**Table 6.**

**Development of Lilly’s Orientation to Science Teaching**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Entry</th>
<th>End of Summer</th>
<th>Fall/Spring</th>
<th>Linda’s Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Views of teaching and learning</td>
<td>• Teaching is telling, learning is listening</td>
<td>• Teaching is telling, learning is listening</td>
<td>• Teaching is telling, learning is listening</td>
<td>• Teaching is telling, learning is practicing</td>
</tr>
<tr>
<td>Views of the teacher roles</td>
<td>• Leader</td>
<td>• Leader/Guide</td>
<td>• Leaders/Guide</td>
<td>• Teach and re-teach (Leader)</td>
</tr>
<tr>
<td>Views of the students roles</td>
<td>• Follower</td>
<td>• Follower</td>
<td>• Follower</td>
<td>• Practice new terms and concepts (Follower)</td>
</tr>
<tr>
<td>Central goals</td>
<td>• Preparing and motivating students for future courses</td>
<td>• Preparing and motivating students for future courses</td>
<td>• NM</td>
<td>• Cover state standards</td>
</tr>
<tr>
<td></td>
<td>• Letting students choose the content they want to study</td>
<td>• For students to apply science to life</td>
<td>• Prepare students for state mandated test</td>
<td>• For students to have fun</td>
</tr>
</tbody>
</table>

Note. NM = Not mentioned
Table 7.

*Development of Jason’s Orientation to Science Teaching*

<table>
<thead>
<tr>
<th>Dimensions:</th>
<th>Entry</th>
<th>Jason’s Orientation</th>
<th>Nancy’s Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Views of teaching</td>
<td></td>
<td>End of Summer</td>
<td>Fall/Spring Semester</td>
</tr>
<tr>
<td>and learning</td>
<td>● Process of discovering knowledge so students can apply science to life</td>
<td>● Process of discovering knowledge so students can apply science to life</td>
<td>● Teaching is telling, and learning is listening</td>
</tr>
<tr>
<td></td>
<td>● Teaching science is providing content through teacher-led discussions and learning is participating in discussions</td>
<td>● Teaching science is providing content through teacher-led discussions and learning is participating in discussions</td>
<td></td>
</tr>
<tr>
<td>Views of the teacher roles</td>
<td>● Guide</td>
<td>● Guide</td>
<td>● Deliver content through lectures and readings (Leader)</td>
</tr>
<tr>
<td></td>
<td>● Discoverer</td>
<td>● Discoverer</td>
<td>● Follow the teacher’s lead (Follower)</td>
</tr>
<tr>
<td>Views of the students roles</td>
<td></td>
<td>● Discoverer</td>
<td></td>
</tr>
<tr>
<td>Central goals</td>
<td>● For students to apply science to life</td>
<td>● For students to apply science to life</td>
<td>● Present content from district curriculum and state standards</td>
</tr>
<tr>
<td></td>
<td>● For students to discover science knowledge on their own</td>
<td>● For students to discover science knowledge on their own</td>
<td>● Provide students with background knowledge</td>
</tr>
<tr>
<td></td>
<td>● Prepare students for future classes</td>
<td>● NM</td>
<td></td>
</tr>
</tbody>
</table>

Note. NM = Not mentioned