CONCEPTIONS OF AND ORIENTATION TO TEACHING SCIENCE OF BEGINNING SECONDARY SCIENCE TEACHERS

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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2007
In memory of my mother, Yvonne, and to my husband, Jeffrey, my constant supporter and friend
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<td>ACP</td>
<td>Alternative Certification Program, a three-year on-the-job program instituted in Florida to prepare uncertified teachers for state certification including classes in education and pedagogy while they are teaching in the public schools.</td>
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<td>Conceptions of teaching science refers to a teacher’s view of science, content knowledge, learners and learning, rationale for instruction and effective instructional strategies (Hewson &amp; Hewson, 1988).</td>
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<td>Orientations to teaching science, refers to a teacher’s knowledge and beliefs about the purposes and goals of teaching science Grossman, 1990, Magnusson et al., 1999).</td>
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<td>PCK</td>
<td>Pedagogical content knowledge refers to a teacher’s ability to explain concepts within a discipline to students that requires expertise in subject matter and teaching skills as well as a knowledge of students and classroom context (Shulman, 1986).</td>
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<td>Pedagogical content knowing refers to a teacher’s understanding of pedagogy, subject matter content, student characteristics, and learning context (Cochran, DeRuiter &amp; King, 1993).</td>
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<td>STTF</td>
<td>Science Teacher Thinking Framework developed by Roberts and Chastko (1990) to show how science teachers think about science teaching events.</td>
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<td>TPC</td>
<td>Teacher pedagogical constructions refer to a model that blends PCK with other teacher knowledge and beliefs (Hashweh, 2005).</td>
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This study aimed to determine Conceptions to Teaching Science (CTS) and Orientations to Teaching Science (OTS) of six beginning secondary science teachers. The teacher participants were in their first year of teaching and came from both traditional and alternative certification preparation programs. The study also examined how useful CTS and OTS were to explore beginning teachers thinking about teaching science. Through interviews and classroom observations, participants articulated CTS that were largely teacher centered. Also, some viewed science teaching as transmission of facts, whereas others saw themselves as facilitating students’ learning. Participants held OTS which mostly complemented their CTS. Overall, they appeared to hold multiple CTS and OTS simultaneously. These results can be used to design new or modify existing pre-service and in-service teacher professional development programs. Also, this study provides a framework for science teachers combining both the CTS and OTS construct.
Science teachers guide their students to construct meaning when making sense of their world. Children’s meaning-making is structured by their cultures and histories and occurs during interactions with students, teachers, parents, and others (Creswell, 2003). During science instruction, to further students’ understanding, their instructors have to be adept at making connections between the concepts to be learned and their student’s prior knowledge. Teachers must therefore have a deep understanding of content and the ability to represent the content in ways that their students will understand through explanation, activities and experiments. Studies on teacher thinking (Bryan & Abell, 2002; Zohar, 2004) have tried to make visible teacher decisions about what to teach, how to teach it, and activities that will best explicate these decisions.

For students to understand and remember scientific concepts, the teacher needs to provide the best content knowledge learning experiences in ways that are understandable for learners. Shulman (1986) speaks about a “particular form of content knowledge that embodies the aspects of content most germane to its teachability” (p. 9). This form of content knowledge Shulman classifies as pedagogical content knowledge. Pedagogical content knowledge (PCK) encompasses the “decisions about content and activities that teachers make, their interactions with students, the selection of assessments, the habits of mind that teachers demonstrate and nurture among their students, and the attitudes conveyed wittingly and unwittingly all effect the knowledge, understanding abilities, and attitudes that students develop” (NRC, 1996, p. 28). The content knowledge a teacher has together with their pedagogical knowledge is transformed by teaching experience and reflection into their pedagogical content knowledge (Shulman, 1986).
PCK embodies a unique form of teacher problem solving that consists of teacher thinking about what difficulties students may have in understanding a particular topic as well as their preconceptions and conceptions about a subject (Shulman, 1986). Teachers need to have both a deep understanding of their subject matter and the pedagogical knowledge to decide what strategies are needed to guide students to realign their conceptions about a topic. They must have curricular knowledge of their science subject matter, how it aligns with the science curriculum, and its position in the total or macrocurriculum of the school (Shulman, 1986).

Individual empirical and meta-syntheses studies have shown how teacher preparation courses and experiences, actual teaching experience, and teacher’s certification status, provide knowledge of teaching and learning, and are strongly related to student achievement (Cochran-Smith, 2002). Adams and Krockover (1997) studied teacher cognition and found that pre-service teaching and learning experiences that is, science methods classes, pre-internship and internship teaching experiences, help develop pedagogical content knowledge. PCK is also mediated by pre-service teacher’s most significant learning or teaching experiences prior to training (Adams & Krockover, 1997).

There are many sources of pedagogical content knowledge besides content and pedagogical knowledge. A teacher must have curriculum knowledge, an understanding of learners and their learning styles, assessment procedures and their evaluation, and an understanding of the various contexts in the classroom (Magnusson et al., 1999). Teacher education programs are designed to prepare new teachers for the classroom by developing their curricular and pedagogical knowledge as well as giving them an understanding of how children learn and strategies to teach and assess them. Personal pedagogical knowledge or the understanding of teaching and management strategies to use in a classroom cannot develop
without practical teaching experiences. These are provided to pre-service teachers through their pre-internship, internship classroom practice as well as other field experiences. As prospective teachers reflect on classroom events as they transpire, they start to identify elements, that is, instructional strategies, teacher-student and student-student interactions, and management techniques, that promote student participation and their subsequent learning in a particular classroom setting (Morine-Desshimer & Kent, 1999). When beginning science teachers enter their first classroom, research indicates that they use their pre-service teaching experiences, academic learning experiences, and belief systems to construct their personal pedagogical knowledge (Morine-Desshimer & Kent, 1999).

One of the current research challenges for educators is to understand teacher thinking when using PCK in the classroom to elucidate concepts about a particular science topic. Studies have shown how teachers (pre-service, new and experienced in-service) conceptualize the particular science they are teaching and the orientations/conceptions they have for teaching science, discovering these through self-efficacy questionnaires, interviews, concept maps, card sorts, and observation.

Pre-service teachers both before, during and after internship have been observed and tested to try to understand how PCK is developed and expanded. New teachers are assumed to have developed a beginning PCK that is fixed but it can be expanded as they become more experienced teachers. New teachers are still developing their PCK and determining their orientation to teaching. Pedagogical content knowledge is not fixed until after that first, second, or third year when the fledgling teacher starts to feel competent to teach the particular subject (Adams & Krockover, 1997).
Because of the many components of pedagogical content knowledge which comprise it, PCK is very difficult to observe. Generally researchers look at a component or components of PCK such as a teacher’s goals and purposes for teaching or their beliefs about teaching which result in instructional strategies used in teaching (Adams & Krockover, 1997; Bryan & Abell, 1999; Friedrichsen, 2002). Two of the ways to examine PCK are by investigating an educator’s orientation to and conceptions of teaching science.

A teacher’s orientation to teaching science encompasses their goals and purposes for teaching particular science content and is observable in the instructional strategies that individual teachers choose when instructing students during specific lessons (Magnusson et al., 1999). Conceptions of teaching science are an educator’s knowledge and beliefs about teaching, the nature of science, and student knowledge and capabilities which result in that teacher’s rationale for instruction and instructional techniques used during teaching (Hewson & Hewson, 1988). It should be possible to determine both of these components of PCK, that is, orientations to teaching science and conceptions of teaching science through observing beginning secondary science teachers instructional strategies and inquiring into their beliefs, goals, and purposes for teaching science.

Beginning secondary science teachers come from a variety of different certification programs, from traditional four or five-year programs to alternative certification programs. Alternative routes to teacher certification generally have specific requirements, that is, that candidates have at least a bachelor’s degree, pass some screening process, like a test or content mastery, use on-the-job teacher training, and take required coursework while teaching either during the school year or in the summer. They also typically have mentor teachers. Such programs last from one to two years (NCEI, 2005).
Darling-Hammond, Chung, and Frelow (2002) using data from a 1998 survey of 3000 beginning teachers teaching in New York City schools, determined teacher comfort with their preparation for teaching. Survey participants were from both traditional college and university four and five-year teacher certification programs and alternate certification programs varying from summer training programs to 1 or 2 year post-baccalaureate programs. The survey of beginning teachers found that 34% of the certified teachers earned it through transcript review and less than half had attained certification through traditional 4-year undergraduate programs (Darling-Hammond et al., 2002).

Teachers from alternate certification programs surveyed felt less prepared than traditionally certified teachers in areas of curriculum, instructional strategies, subject matter content, and understanding and knowing how to meet student needs (Darling-Hammond et al., 2002). All of these areas are components of a teacher’s pedagogical content knowledge, specifically elements of their conceptions of teaching and orientations to teaching. The study also found that teachers from certified programs had a higher sense of responsibility for student learning whereas, teachers from alternative programs felt that students were responsible when they were not learning the material (Darling-Hammond et al., 2002).

One of the topics that is yet unknown is, what a teacher is thinking when s/he uses PCK in the classroom to elucidate concepts about a particular science topic. Studies have shown through self-efficacy questionnaires, interviews, concept maps, card sorts, and observation how pre-service, novice and expert teachers conceptualize the particular science they are teaching based on their orientations and conceptions about teaching science (Adams & Krockover, 1997; Friedrichsen, 2002; Zohar, 2004). Orientations toward teaching science and conceptions of teaching science are distinct components of pedagogical content knowledge with some overlap.
Both orientations to teaching science (OTC) and conceptions of teaching science (CTC) contain a teacher’s rationale for teaching and preferred teaching strategies, but conceptions of teaching science view the rationale for instruction and preferred strategies as only two of its five components whereas orientations toward teaching science sees them as the evidence that exemplifies a teacher’s goals for teaching (Magnusson et al., 1999). Exploring the nexus (Figure 1-1) between a beginning teacher’s orientations to teaching science and conceptions of teaching science should illustrate the beginning teacher’s thinking on secondary science instruction.

**Purpose of the Study**

The present study will explore the orientations to teaching science and conceptions of teaching science of first year secondary science teachers from both traditional and alternate teacher certification programs. The researcher poses these questions to guide the study:
Research Questions

- **Research Question 1:** What are the conceptions of teaching science of the six beginning secondary science teachers in this study?

- **Research Question 2:** What is the nature of orientations to teaching science of the six beginning secondary science teachers in this study?

- **Research Question 3:** To what extent does CTS and OTS help elicit beginning science teachers thinking (PCK)?

Definition of Terms

- **Conceptions of Teaching Science (CTS).** A teacher’s view of science as well as their “knowledge of the particular content to be taught, the particular students they will be teaching, and effective instructional strategies to plan and perform to achieve the intention of helping these students learn the desired content” (Hewson & Hewson, 1988, p. 611).

- **Orientation to Teaching Science (OTS).** A teacher’s knowledge and beliefs about the purposes and goals of teaching science (Grossman, 1990; Magnusson et al., 1999).

- **Pedagogical Content Knowledge (PCK).** A teacher’s ability to explain concepts within a discipline to students that requires expertise in subject matter and teaching skills as well as a knowledge of students and classroom context (Shulman, 1986).

- **Beginning Secondary Science Teachers.** Individuals who are starting their first assignment as a science instructor in a middle school or high school environment.

- **Route to Teacher Preparation.** The different pathways that an individual can take to be licensed as an educator. Two different pathways are considered:

  - **Traditional Certification.** A college or university-based four-year program to train individuals to teach a particular subject matter. This program includes coursework in the content individuals will be teaching, education and pedagogy courses, and practice teaching with varying levels of support and supervision. At the culmination of the program, individuals take state tests to certify them as subject matter or grade level teachers.

  - **Alternative Certification.** A one to three year program administered by colleges or universities, states, or other agencies to train individuals having a bachelor’s degree to teach and generally includes coursework in education and pedagogy, on-the-job training while teaching, mentoring by seasoned teachers, and passing general knowledge, subject area, and professional educator’s exams to become certified.
Significance of the Study

This study will explore first year secondary science teachers’ orientations to teaching science and their conceptions of teaching science. The findings will contribute to the body of scholarly research in science teacher thinking regarding teachers’ orientations to teaching science and conceptions of teaching science. The findings may be helpful in designing or modifying pre-service teacher education programs. The findings may also guide professional development of in-service teachers and encourage participants to examine prior teaching or mentoring experiences and how they influence teacher practice, carefully selecting cooperating teachers to give pre-service teachers a chance to see and practice teaching strategies they may be unfamiliar with and resistant to, and ensuring education classes are current and relevant to the student population and school climate new and practicing teachers encounter. This study will contribute to theoretical key concepts of teacher thinking by combining CTS and OTS and providing a new model for beginning science teacher thinking.

Furthermore, this study should contribute to the literature on science teacher thinking that uses the CTS and OTS constructs. These constructs are used differently in some literature and interchangeably in others. It is hoped that this study will provide new insights into the usefulness of these constructs for describing how beginning science teachers think about their teaching.

Limitations of the Study

1. Only individuals who met the criterion of being beginning secondary science teachers were eligible for participation in this study.
2. Participants in this study were not necessarily representative of all beginning science teachers.
3. Perceptions of individuals are limited to their point of view.
4. Possible sources of participant’s orientation to teaching science were not reported on.
5. Data was chosen to be collected after participants had been teaching for at least one month to enable them to settle into their classrooms and resolve any administrative issues that would have distracted from the teaching.
CHAPTER 2  
LITERATURE REVIEW

How an educator teaches depends on their beliefs, vision of teaching, content knowledge, pedagogical knowledge, understanding of students and of the context of instruction within their classroom, school and community (Magnusson, Krajcik & Borko, 1999). Teaching is not an automatic act but a purposeful action that requires each educator to take all of the components and construct their conception of and orientation to teaching. This is not done in a vacuum, rather “all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context” (Crotty, 1998, p. 42). A constructivist framework is necessary to guide any observations into teacher thinking, pedagogical content knowledge, and orientations to teaching. In this chapter I will provide an overview of research related to the study. The following topics, teacher thinking, pedagogical content knowledge, science teaching orientations and conceptions of teaching science will precede a summary.

Teacher Thinking

Teacher thinking comprises a huge body of research on reflection where teachers engage in thoughtful, deliberative self-examination of teaching events. Two studies (Halkes & Deijkers, 2003; Roberts & Chastko, 1990) developed frameworks for teacher thinking, but the remainder of the studies (Zohar, 2004; Windschitl, 2003; Bryan and Abell, 2002; Shapiro, 1996; Adams & Krockover, 1997) discussed teacher thinking in general.

Halkes & Deijkers (2003) suggested a cognitive action framework to guide teaching. They asserted that the novice or experienced teacher needs to have built a routine or theory about what to do in the pre- or inter-active teaching-learning situation. Teacher beliefs determine what
to do, what to avoid and what to work toward in teaching. A teacher's personal values are important and the teacher tries to keep them constant while teaching (Halkes & Deijkers, 2003). From the literature the authors compiled a teacher's criteria for instruction: 1) student activity and participation; 2) adaptations to student differences; 3) subject matter; 4) teacher’s pedagogical aims or objectives; 5) nature of teacher-student and student-student interactions; 6) teacher’s needs for certainty, autonomy, respect; and 7) what orientation teacher held on basic knowledge, discipline and objectivity (Halkes & Deijkers, 2003). In this study on teacher thinking they found that science teachers were like language teachers in that they wanted more teacher control, needed less work ethos, and preferred direct instruction as their teaching orientation within their classrooms.

Roberts and Chastko (1990) developed the Science Teacher Thinking Framework (STTF) to show how science teachers think about science teaching events. They posited that reflection or thinking about the events of science teaching is compared with absorption (simply taking information in) and refraction (bending away or ignoring the information). A science methods course was taught using the STTF construct which had four parts, i.e., subject matter, teaching strategy, objectives, and student response. First reflective category is subject matter, which shows student's theoretical framework. The next category, teaching strategy, shows the intentional character of teaching where subject matter is blended with teaching strategies. Objectives, the third category, are concerned with outcomes for students and how they are linked to the actions of the teacher. The fourth category was student’s responses comprised as feedback to teachers on how their lesson is being understood by students (Roberts & Chastko, 1990).

In the study the researchers examined whether the quality of student’s reflection can be affected by the content and instruction in the methods course. Pre-service secondary science
teachers come to the methods course with preconceived notions about the purpose of learning which Roberts and Chastko called absorption. Students see coursework as something to be learned as fact. The methods course was taught from a constructivist stance to help students learn concepts as a lens to look at events and make sense of them. Authors found that some students resisted the reflection of microteaching and talking about the teaching because of their subject-matter-as-fact orientation. Three refractory styles, i.e., "who needs this", "everything-was-fine", and "haven't you forgotten something" were the ways that students resisted the constructivist style and STTF construct they were being taught (Roberts & Chastko, 1990). The authors found that their students developed reflective abilities at different levels and from resistance of reflection to acceptance of it, and the reflective stance supported their teaching orientation.

Zohar (2004) found that secondary science teachers, when trained in a new teaching curriculum, resisted the concept of allowing students to create their own scientific meaning. Teachers were more comfortable with the transmission-of-knowledge form of teaching and believed teacher thinking should have the same focus. In the study two-thirds of the teachers used the transmission-of-knowledge model and less than one-fourth used constructivism. The author found that the kind of inquiry pre-service teachers experienced as students in science classes was confirmatory or cookbook labs i.e., follow the steps and get the prescribed answer. These labs patterned the kind of experiences pre-service teachers had in high school science. Their high school teachers also did not engage students in discussions about science topics (Zohar, 2004).

Another finding was (Zohar, 2004) that pre-service teachers had never experienced inquiry so they had no schema for understanding it. Without discussion and activities to help understand science, teachers will not be able to learn new information or discuss why something
is or is not correct knowledge. The experiences that influence teachers’ conceptions and beliefs about inquiry are their K-12 experiences, lab work at the college level and teacher education courses (Zohar, 2004).

In Windschitl’s (2003) study, reflective journals were used in a preservice science methods class to examine teacher thinking. The student’s reflections ranged from foci on aspects of teaching, learning and subject matter to the moral, social, and political aspects of teaching. He found that the beliefs each pre-service teacher carried strongly influenced their thinking and actions. He believed that teachers make instructional decisions based on their knowledge and beliefs and the interaction between them. From interviews and reflections he discovered that preservice teachers understanding of inquiry was learned when they are undergraduates. Those teachers who understood inquiry had more rich reflections and tended to think more about how they would present the activity to their own students. Those who thought inquiry was a linear process just kept a log-like journal with only the data. Only half of the pre-service teachers used inquiry in their classrooms and those who had done inquiry before were those who transferred it to their classrooms (Windschitl, 2003).

Bryan and Abell (2002) reported in a single case study about a pre-service teacher's beliefs, experiences and tensions in her teaching. The teacher’s vision of science included beliefs on how children learn science, goals of science instruction and the role of the science teacher, components of a teacher’s orientation to and conceptions of teaching science. As her teaching progressed she was able to think about her student's lack of science concept understanding. These reflections led her to see disconnects between her beliefs and her actions. She began to look at her teaching instead of the students' perceived shortcomings and process her beliefs, visions, and practice into the orientations to teaching that were most realistic for her (Bryan &
In a study of changes in elementary student teacher thinking in science methods classes (Shapiro, 1996) looked at inquiry projects done outside the class with a partner. Most students in a method class changed their thinking about science and investigations as a result of their project-based inquiry. A participant, chosen as a model case study, reversed her ideas about how to perform open-ended investigations, what science is, and the usefulness of investigations as a learning approach in the classroom (Shapiro, 1996).

In “Beginning teacher cognition” (Adams & Krockover, 1997), the authors give Kagan’s (1990) definition of teacher orientation as "pre- or in-service teachers' self-reflections beliefs and knowledge about teaching, students, and content; and awareness of problem-solving strategies endemic to classroom teaching” (p. 635). They studied four beginning secondary science teachers to examine their thinking and how it relates to the program experiences they say built their knowledge. The four participants included three biology teachers and one earth science teacher. While the participants credited the pre-service program with helping them develop constructs on student-centered learning, general pedagogical knowledge and pedagogical content knowledge, models for instructional strategies or orientations to teaching came from experiences other than the education classes for two of the four teachers. These two used lecture extensively as they had been taught most of their student lives. "The degree of translation from the program to the teacher’s understanding of their classrooms appears to be modulated by their most significant learning experiences and the context of their teaching situations” (Adams & Krockover, 1997, p. 649).

**Pedagogical Content Knowledge**

Pedagogical content knowledge (PCK) is a context specific knowledge of how to teach a particular subject to a particular group of students. Representations, demonstrations, questioning
techniques, and other strategies can be used to explain specific concepts within their subject matter to students. Experienced teachers tend to have higher PCK due to their amount of time in the classroom. The term was first coined by Shulman who placed it within the seven categories of knowledge that teachers must have to perform well, i.e., knowledge of content; knowledge of pedagogy; knowledge of curriculum; knowledge of learners and learning; knowledge of contexts of schooling; pedagogical content knowledge; and knowledge of educational philosophies, goals, and objectives (Shulman, 1986). He defined PCK as the combination of content knowledge and pedagogy transforming by teaching experience and reflection, used to explain concepts within a particular discipline to students in the classroom and stated that it “goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching” (Shulman, 1986, p. 9).

Grossman (1990) took the seven categories of knowledge and refined them into four categories: subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge and knowledge of context. General pedagogical knowledge was redefined to include knowledge of educational philosophies, goals, and objectives. Within pedagogical content knowledge there were four components, i.e., conceptions of purposes for teaching subject matter, knowledge of learners and learning, curricular knowledge and knowledge of instructional strategies. Each component was fed from the other categories of knowledge, namely subject matter, general pedagogical knowledge, and knowledge of content (Figure 2-1).

What drove PCK was a teachers understanding of purposes for teaching their particular subject and their beliefs about them. These conceptions showed themselves as goals for a specific subject, explicating different beliefs by the different aims teachers had for instruction. Knowledge about students included not only students’ conceptions but their misconceptions on a
particular subject at specific grade levels. Curricular knowledge demonstrated teachers’ depth and breadth of a particular subject, showing their understanding not only of the concepts within a subject but how it fit within the overall discipline. Knowledge of instructional strategies explained the techniques used in teaching a subject. Master teachers developed “rich repertoires of metaphors, experiments, activities, or explanations” (p. 9) to guide their instruction (Grossman, 1990). Magnussen, Krajcik, and Borko (1999) used Grossman’s model of PCK but added a fifth component, assessment in scientific literacy.

![Figure 2-1. Model of domains of teacher knowledge in PCK. Modified from Magnusson, Krajcik, and Borko (1999)](image)
In the literature, PCK appears to be related to the concepts of functional paradigms (Lantz & Kass, 1987), craft knowledge and pedagogical content knowing (Van Driel et al., 1998), and achievement goal theory (Deemer, 2004). Functional paradigms (Lantz & Kass, 1987) was first presented by Crocker (1983) who used it as a way to investigate why teachers function as they do and how this affects the classrooms they teach in, and vice versa. Lantz and Kass looked at the reflective practices of high school chemistry teachers whereby they translated particular curricular materials (ALCHEM) into classroom practices. From interviews of 20 in-service teachers they formulated a picture of functional paradigms of teaching chemistry. As with Grossman’s study, the authors found three sources for teachers’ functional paradigms, namely curriculum materials, teachers’ background, and their teaching situation. All of these sources were colored by a teacher’s perception of high school chemistry.

A team of researchers (Van Driel et al., 1998) searched the literature on pedagogical content knowledge (PCK) and craft knowledge to determine if they were synonymous and what ties they had to each other. They found that craft knowledge was greatly influenced by a teacher’s conceptions of teaching science. They defined craft knowledge as “integrated knowledge which represents teachers’ accumulated wisdom with respect to their teaching practice.” (Van Driel et al, 1998, p. 674) The authors also agreed with Shulman’s (1986) sources of PCK, namely observation of classes; disciplinary education; specific courses during teacher education; and classroom teaching experience.

A slight variant on PCK was PCKg or pedagogical content knowing, defined as “a teacher’s integrated understanding of four components of pedagogy, subject matter content, student characteristics, and the environmental context of learning” coined by Cochran, DeRuiter
and King (1993, p. 264) and was believed to be a synthesis of all four components developed at the same time.

Achievement goal theory was used in another study (Deemer, 2004) to study the influence of teachers’ teaching efficacy on their classroom goals. This seems to parallel the overarching component of Grossman’s PCK, namely conceptions for teaching. Deemer saw a correlation between efficacy and instructional practice in her study that is how confident a teacher was translated to the structure and goals of their classroom. Other factors fed into these teacher efficacies, such as beliefs about student intelligence, and perception of school climate, which resulted in a teacher’s classroom goal orientation (Deemer, 2004).

**Orientations to Teaching Science**

Orientations to teaching science (OTS) is placed within PCK as the overarching component (figure 2-2) but different researchers have named or defined each term in slightly different ways and cited as many as nine orientations or as few as two depending on the study. Hewson and Hewson (1988) identified four distinct teaching approaches based on the study by Anderson and Smith (1983) as activity-driven, didactic, discovery, and conceptual change teaching. The authors placed them on a continuum from inexperienced to experienced teachers, placing the activity-driven teaching technique as that chosen by least experienced teachers, and didactic as used by those who see teaching as a process for presenting information to students, and discovery and conceptual change teaching as that chosen by most experienced teachers. Grossman (1990) called this component of pedagogical content knowledge the “conceptions of purposes for teaching” and made it the overarching component within PCK. Although she did not name specific conceptions she believed that a teacher’s perspectives seemed to suggest their different conceptions of teaching.
Magnussen, Krajcik, and Borko (1999) also felt that there was an overarching component within PCK but named the umbrella component “orientations to teaching science” (Figure 2-1) and had it shaping the other four components of pedagogical content knowledge. They defined OTC as “teachers’ knowledge and beliefs about the purposes and goals for teaching science at a particular grade level” (p. 97) and found what they termed nine orientations to teaching science
within the literature. The orientations were organized on a chart from process or content to a combination of both that would fit into the new inquiry-based standards. Process and activity-driven orientations fit on the process end of the continuum whereas academic rigor and didactic orientations were on the content end. Conceptual change, discovery, project-based science, inquiry and guided inquiry were both process and content oriented and would be located in the middle. A second continuum depicted teacher-to-student centered instruction where academic rigor and didactic orientations existed on the teacher-centered end and activity-driven, guided inquiry, project-based science, conceptual change, and inquiry moved along the continuum toward a purely student-centered orientation that terminated with discovery learning (Magnusson et al., 1999). All orientations were teaching strategies chosen depending on what teachers felt were the goals for teaching science.

In a study (2002) of four highly-regarded student-centered biology teachers Friedrichsen found that the orientations Magnussen, Krajcik, and Borko (1999) identified did not fit her teachers’ views of instruction. She discovered that the teachers had complex science teaching orientations and appeared to hold more general beliefs of a teacher’s role in instruction. Her substantive-level theory proposed that science teaching orientations had multiple components with different components having more important roles where other roles were on the periphery (Friedrichsen, 2002).

Sandra Deemer (2004) used a simple achievement goal orientation system for studying teacher’s behaviors. Teachers would either use mastery or performance orientations in their classrooms depending on several factors, specifically teacher’s personal beliefs or self-efficacy, how they define intelligence, and their beliefs about school access and resources. High self-efficacy was equated to experience and comfort with teaching. How teachers viewed their
students abilities depended on their view of intelligence. An entity belief of intelligence was viewed as fixed whereas an incremental belief imagined that intelligence is malleable and can be increased. Finally, teachers in school cultures with a mastery or performance goal outlook were usually given materials and training to support innovation and provide equal access. A performance-oriented focus supported competition among teachers and selective access to resources (Deemer, 2004). High self-efficacy and a belief in incremental intelligence usually supported a teacher with a mastery orientation whereas low self-efficacy and an entity intelligence belief usually resulted in a teacher with a performance-oriented teaching disposition. School context played into these orientations in many cases but not all.

**Conceptions of Teaching Science**

Science teachers need to be able to facilitate students actively constructing their own knowledge. They need to plan lessons around whatever students know and need to know. The skills, knowledge, and altitudes a teacher possesses depend on their own conceptual structures of classroom events, combined with their pedagogy and how they explain concepts. These also depend on a teacher's rationale for teaching, view of science, orientations to teaching, science content, student understanding and school context. Hewson and Hewson called this construct the teacher's conception of teaching science and gave it five components (figure 2-3), conceptions of science, conceptions of teaching, learner characteristics, rationale for instruction, and preferred instructional techniques (Hewson & Hewson, 1989).

Hewson and Hewson’s (1988) conception of teaching was based on the Hirst-Fenstermacher framework (1971; 1986) which requires four components for an activity to be classified as a teaching activity. First, for teaching to occur, there must be learning. Second, the learning must be focused toward an outcome. Third, the teacher must support the student and
Figure 2-3. Conceptions of teaching science. Modified from Hewson and Hewson (1989)
improve their capacity to achieve their learning goals. Fourth, the teacher has an end object, to teach a student.

Hewson and Hewson (1988) state that "science teaching should of necessity consist of tasks and activities which are intended to help particular students learn particular content... indicative of the particular content to be learned, and expressed so that it is possible for the particular students to learn it" (p. 601). Internal characteristics science teachers should possess, called conceptions of teaching science, include: 1) a clear conception of teaching; 2) knowledge of content; 3) an understanding of student conceptions and alternate conceptions about the topics to be taught; 4) knowledge and use of instructional strategies that bring about student conceptual change; and 5) the ability to use all of the knowledge to facilitate student learning (Hewson & Hewson, 1988).

Hewson and Hewson (1989) developed a task for identifying teacher’s conceptions of teaching science and a clear analysis of the task. They defined conceptions for teaching as a "set of ideas, understandings and interpretations of experience concerning the teacher and teaching, the nature and content of science and the learners and learning which the teacher uses in making decisions about teaching, both planning and execution (p 194). The task presented the teacher with instances from their science field and asked whether it was an example of teaching or not. It provided instances and non-instances of science teaching in and out of class. The conceptions of science teaching task was tested on 30 secondary science pre-service teachers and was analyzed using six categories, i.e., a teacher’s understanding of the nature of science, whether they felt learning was happening, what learner characteristics were involved, their rationale for instruction, their preferred instructional techniques, and their conception of teaching science (Hewson & Hewson, 1989).
**Routes to Certification**

Teacher certification means that an individual who wishes to teach is qualified and licensed to do so. Licensure is meant to assure the public that professionals such as doctors, lawyers, and teachers are competent, fully qualified, and will do no harm (Diez, 2002). States control licensing of teachers and other professionals and require proof of education and a background free of criminal offenses. These state standards also prescribe specific coursework that teacher candidates must have. States also screen candidates for competency with tests of basic literacy skills and mathematics.

In recent years the passage of the No Child Left Behind mandate requires that all teachers must be fully qualified by 2005-2006 (Sindelar, Daunic & Rennells, 2004). Now state and federal agencies must assess professional skills and subject matter understanding to determine whether a teacher is highly qualified (Diez, 2002). There are two routes to teacher certification, the traditional route and alternative certification.

Traditional certification refers to the college or university-based four-year program to train individuals to teach a particular subject matter. This program includes coursework in the content individuals will be teaching, education and pedagogy courses, and practice teaching with varying levels of support and supervision. At the culmination of the program, individuals take state tests to certify them as subject matter or grade level teachers.

A huge turnover in teachers is expected in the next few years. The U.S. Department of Education (2001) reports that a much as two million new teachers will be needed by 2010 and programs in 46 states and the District of Columbia that provide an alternate route to attaining teacher certification are getting more attention (Thomas, Friedman-Nimz, Mathlios, and O’Brien, 2005). Alternate certification is a relatively new path to teaching being used more frequently by
school systems and states due to the shortage of traditionally certified teachers specifically in the fields of science, mathematics, and special education (Sindelar, Daunie & Rennells, 2004).

Alternative certification refers to a 1 to 3 year program administered by colleges or universities, states, or other agencies to train individuals having a bachelor’s degree to teach and generally includes rigorous screening process, professional education coursework, on-the-job training while teaching, mentoring by seasoned teachers, high performance standards (Thomas, et al., 2005) and passing general knowledge, subject area, and professional educator’s exams to become certified.

Summary

Studies on pedagogical content knowledge and orientations to or conceptions of teaching science demonstrate that there is a paucity of research on the PCK of beginning teachers. Pre-service teachers both before, during and after internship have been observed and tested to try to understand how PCK is developed and expanded. New teachers are assumed to have developed a small amount of fixed PCK that can expand until they become experienced and/or exemplary teachers. It has been posited that new teachers are still developing their pedagogical content knowledge and determining their orientation to teaching. Bryan and Abell (1999) reported that these two areas of teacher thinking and practice are not fixed until after that first, or second, or third year when the novice teachers start to feel competent to teach the particular subject.

Additionally when the teacher is asked to teach a different science discipline, pedagogical content knowledge for the new subject also has to be developed. (Bryan & Abell, 1999).

One of the topics that is yet unknown is what a teacher is thinking when s/he uses PCK in the classroom to elucidate concepts about a particular science topic. Studies have shown how pre-service, novice and expert teachers conceptualize the particular science they are teaching based on their orientations and conceptions about teaching science (Adams & Krockover, 1997;
Friedrichsen, 2002; Zohar, 2004), and findings illustrate this through self-efficacy questionnaires, interviews, concept maps, card sorts, and observation. Orientations toward teaching science and conceptions of teaching science are distinct components of pedagogical content knowledge with some overlap. Both OTC and CTC contain a teacher’s rationale for teaching and preferred teaching strategies, but conceptions of teaching science sees the rationale for instruction and preferred strategies as only two of its five components whereas orientations toward teaching science sees them as the evidence that exemplifies a teacher’s goals for teaching (Magnusson et al., 1999). Exploring the nexus between a beginning teacher’s orientations to teaching science and conceptions of teaching science should illustrate the beginning teacher’s thinking on secondary science instruction.
Theoretical Framework

“Interpretivism is a defining element of all qualitative research” says Hatch (2002) and “permeates everything that is done” (p. 179). Interpretivists believe that “social actors” negotiate meaning about their world by attempting to interpret it and “subscribe to a realist ontology” (Scott & Morrison, 2006, p. 131). Researchers engage in taking a reported account of an individual’s actions and explaining it. In other words, they interpret data by giving a particular thing meaning in alignment with their beliefs and understanding and make sense of it by giving their explanations of what it means (Hatch, 2002). Interpretivism gives a model which aligns the researcher as one of the active members in research. The problem is whether the researcher can adequately interpret the participant’s account without distorting what they try to describe.

Interpretation is expressed best in studies using interviews which focus on how the participants construct meaning of their reported activities and actions (Scott & Morrison, 2006). The researcher therefore chose interpretivism as the methodological theoretical framework analyzing data collected in the study. The steps of interpretive analysis clarified by Hatch (2002) were followed in this study. First, the researcher reads all of the data through, then looks to research for impressions of the data that might have been found and reported on. Second, he/she reads the data again looking for these and other impressions. Data are read a third time and coded based on support for or challenges to the researcher’s interpretations. Fourth, the researcher writes the summary. A member check is performed with participants for the fifth step, and finally, the researcher writes the revised summary. By ensuring that all of these steps are taken the study allows the data to speak both for the participants and researcher.
The Study

This study explores the orientations to and conceptions of teaching science of first year secondary science teachers. The researcher posed these questions to guide the data collection within the confines of the study:

- **Research Question 1**: What are the conceptions of teaching science of the six beginning secondary science teachers in this study?

- **Research Question 2**: What is the nature of orientations to teaching science of the six beginning secondary science teachers in this study?

- **Research Question 3**: To what extent does CTS and OTS help elicit beginning science teachers thinking (PCK)?

Research Design

The qualitative research design for this study was chosen for a variety of reasons. First, the researcher was “interested in understanding the meaning people have constructed,” (p. 6) specifically how these beginning science teachers make sense of their experiences within the context of their beliefs and goals (Merriam, 1998). Second, the researcher was the primary instrument of this study, acting as interviewer and participant observer of the teachers as they experienced teaching in their first year. Third, the research questions required the researcher to collect information in the field about beginning secondary science teachers in their natural setting, the classroom. Fourth, the data consisted of observation and interview which were interpreted within the context of each participant’s background. Analyzing the data, the researcher would “build toward theory from observations and intuitive understandings gained in the field” (p. 7). Finally, data from this study produced rich descriptive data about these beginning secondary science teachers, their beliefs, goals, and purposes of science instruction and their preferred instructional strategies.
Since several teachers were observed and interviewed to learn about their orientations to and their conceptions of teaching science, the multiple case study methodology was chosen. Multiple case studies are used where there are several cases which are fully described from the data, collected and analyzed, then cross-case analysis is done of the similarities and differences between cases (Merriam, 1998). This type of study tends to enhance the generalizability and external validity of the findings. The case in this collective study was a group of teachers. It also needs to be about a specific person or phenomena, otherwise known as a bounded system (Stake, 1995).

An attempt was made to select study participants for this research on the basis of maximum variations sampling where the researcher looked for teachers with the widest possible range of characteristics (Merriam, 1998) like type of certification, different teaching environment, prior teaching experience, and so on. These differing characteristics gave the study variety and balance, while also allowing the researcher to learn about the phenomena being studied (Stake, 1995). Due to the paucity of available candidates, selection was made on their status as beginning secondary science teachers and willingness to be part of the study. It was fortuitous that due to the wide range of experiences, content specialty, different teaching environment and type teaching certification of the participants this balance occurred without using sampling.

Qualitative research has a strong emphasis on interpretation rather than generalizations. Since there are only a few elements within the case study, they are traditionally not used to make generalizations. The researcher doing fieldwork attempts to record what happens objectively but also makes meaning of what is seen. Observation was then focused to look for support or non-support of this meaning-making and finally, assertions or conclusions to the meanings of the data
collected are found. Conclusions like inferences in science are the mixture of what we observe, what we know and what we believe (Stake, 1995).

Case study data like data from other methodologies can come from artifacts, interviews, observation and other documentation. The design consists of five parts: research questions, propositions, units of analysis, showing how the data are linked to the propositions and criteria that allows interpretations of the findings (Zucker, 2001). My unit of analysis was beginning secondary science teachers in their first classroom assignment so my case study goal was to describe the case, beginning secondary science teachers’ orientations to science and conceptions of science as fully as possible. To do this I observed patterns in the data, clustered like data together, made metaphors and comparisons, noted relations between teachers, built a logical chain of evidence for what I saw, and made conceptual/theoretical coherence of the data (Zucker, 2001).

Beginning science teachers are relatively inexperienced with teaching in real-world classrooms, having in most cases spent only limited time observing and instructing students under the cognizance of a cooperating teacher. They have attained a science content degree in physics, chemistry, biology, geology, astronomy or other related science fields from an accredited college or university. To be certified as a secondary science teacher, teacher candidates must have successfully completed educational pedagogy and curriculum course work. Graduates of a certified teacher education program have experienced classroom observation and teaching in a protected environment under the direction of cooperating teachers and college administrators whereas teachers from alternative certification programs have content knowledge but may have little pedagogical knowledge and limited classroom observation and practice teaching depending on the program (Cochran-Smith, 2002). Both groups of teachers have their
first opportunity to prepare and teach meaningful learning activities in their own classroom to explain science content knowledge to groups of adolescents. Developing the techniques needed to teach a subject requires the development of pedagogical content knowledge, some conception of science teaching, and an orientation or orientations to teaching that guide their practice.

**Setting and Participants**

All of the beginning teachers earned a Bachelor of Science degree in a range of subjects, that is, sports medicine, biology, ecology, and biology/earth science education. They all started their first year of teaching in a public or private K-12 school in the fall of the year this study was begun.

Six individuals beginning their first year of teaching secondary earth and space science, chemistry, anatomy and physiology, or biology were selected. Only one of the participants was from a traditional university-based teacher certification program. The remaining five teachers had degrees that ranged from a bachelor’s to a master’s degree in science and were in the process of becoming alternatively certified through the state or schools. One of the five participants obtaining his alternate certification passed his certification exams prior to starting his first year as a science teacher. The researcher focused on four science disciplines, that is, secondary earth and space science, chemistry, anatomy and physiology, and biology as they corresponded with participants’ degrees and teaching assignments.

Additionally, finding one traditionally certified and five alternately certified beginning secondary science teachers allowed me to examine the similarities and differences related to their route to teacher preparation. To locate beginning secondary science teachers, local principals, school boards, and university professors were contacted to develop a pool of possible candidates. Participants were selected based upon their willingness to participate in the study.
Gaining access

Secondary school systems have only a finite number of new science teachers and of these, few chose to be participants in my study. In order to develop a sizeable pool of participants I elected to expand my search to as many counties near my location as I needed to find the requisite number of participants for my study. Each county had specific requirements for access to their teachers.

County One

County One is the home to seventy-three schools teaching 29,108 students and within the county there are twenty-five elementary schools, eight middle schools, seven high schools, and fifteen special needs schools (FL DOE, 2005a). I contacted the Science Coordinator for County One who provided me with a list of potential teacher candidates. The Director of Research, Evaluation, and Testing for this county informed me that the school district was the location for over 300 studies per year since a large research intensive university resides within the district. He made all determinations concerning researchers allowed access to County One and required a completed permission form for each requested school (see Appendix F), an approved IRB request and IRB protocol (see Appendix A), and one copy of any instrument to be used. Ten days after receiving all documentation, the director approved the request.

Next he sent each form to the named school to allow principals to determine whether they would allow a researcher access to their teachers. Of the six schools requested, only three principals responded, one conditionally, and of the four teachers within the schools, only two agreed to the study. Both teachers were in rural schools, one to the north of the county and one to the south.
County Two

To the southeast of County One and adjoining it County Two was located, approximately twice as large as county one and with one medium size city and many small townships. The school system included twenty-seven elementary schools, seven middle schools, one combined elementary and middle school, seven high schools, three charter schools, and fourteen special needs schools with a total of 39,650 students enrolled (FL DOE, 2005b). I contacted the Director of Guidance and Assessment by phone who requested a project summary of my research study and a copy of my approved Institutional Review Board (IRB) protocol. Subsequent email communications wherein the materials were sent and received resulted in approval being given for the study. The director then requested written documentation from my supervising professor indicating that the study of beginning teachers was approved. Contacting the senior secretary of the department at my university, I attained the signed dissertation proposal form (see Appendix F) and faxed it to the director.

Subsequently I sent a summary of my plan for teachers and their principals and a letter of informed consent. The director requested copies of whatever written communications I planned to use with principals and teachers. I contacted the principals via email using the same project summary given to the director but tailored to each school (see Appendix F), and followed-up with phone contact to attain access.

The Director of Guidance and Assessment for County Two also offered the services of their personnel department to create a database to identify any first-year secondary science teachers that they had. I received a written authorization from the director that my study was approved in her county and two weeks later purchased a database of the beginning secondary science teachers in their county. The list included the names of seventeen teachers as well as those with temporary three-year certification. Of these, thirteen teachers from nine middle
schools and high schools were in their first year of instruction. I emailed and phoned the principals from all of the schools with new teachers but was refused access by three of them citing worries that their new teachers were busy teaching and attaining certification and had no time for participation in the study. Principals from an additional three schools never returned emails or phone calls. Two teachers from the remaining schools refused to participate and one dropped the study after the initial interview explaining that his large workload prohibited participation. I was able to secure one participant from the public schools in this county.

**County Three**

I found one principal in County Three who wanted me to meet his two new teachers and invite them to participate in my study. County three is a rural county in central Florida with five elementary schools, two junior high/middle schools, one combined middle and high school, two high schools, three charter schools, an adult school and three other non-specified schools with a total of 7,022 students enrolled (FL DOE, 2005c). I contacted both teachers via email and one contacted me, becoming the fourth teacher in my study.

**Private Schools in Counties Two and Four**

Finally it was suggested to me that I might find likely candidates for the study among teachers at private schools in the area. I developed a list of private schools in four surrounding counties, preparing to widen the search to more outlying counties if necessary. County Two had several schools with religious affiliation. When I contacted a well-established private protestant school, the headmaster suggested I contact a recently built local Catholic high school where he believed there were two new science teachers. I contacted the high school and was given permission to contact their two beginning secondary science teachers. One teacher accepted my invitation to join the study making five participants. Canvassing the private schools in County
Four I located my sixth teacher candidate at a non-sectarian private academy. The entire process of finding study participants took five months.

**Data Collection**

In this qualitative research study, the researcher is the primary instrument, acting as interviewer and participant observer of the participants, the secondary science teachers as they developed experience teaching in their first year. The research questions presented earlier in this chapter required the researcher to collect information about beginning secondary science teachers in their natural setting, the classroom. Data from this study provided data about the beginning secondary science teachers, their beliefs, goals, and stated purposes of science instruction and their preferred instructional strategies.

The data collected consisted of observations and interviews. Data were interpreted within the context of each participant’s background. This allowed the researcher to use the data collected to develop unstinting description of the beginning science teachers’ profiles. Other data sources used were semi-structured interviews, unstructured observation, and researcher field and analytical notes.

The researcher strategically selected to collect data from participants after they taught for one month to allow them to settle into teaching and resolve administrative issues. Data was collected for each participant over a one-week period at the start of a teaching unit. This timeframe allowed the researcher to see a snapshot in time of the participant’s teaching practice. Due to access issues and teacher convenience, beginning secondary science teachers were interviewed and observed between the periods of October 2005 through June 2006 (see Appendix G).
Interviews

The interview was used to elicit participants’ perspectives and since its quality was largely dependent on the skill of the interviewer (Patton, 2002) the researcher needed to be experienced in interviewing or have a well-structured interview protocol. Semi- and unstructured interviews encouraged participants to respond open-endedly and allowed the researcher to look for in-depth understanding of the experiences of these individuals (Scott & Morrison, 2005). For this study, the researcher combined approaches, and used the standardized open-ended interview for the initial interview and a semi-structured interview guide for post-observation interviews (Table 3-1).

Table 3-1. Explanation of interview types.

<table>
<thead>
<tr>
<th>Type and timing of contact</th>
<th>Type of interview</th>
<th>Purpose</th>
</tr>
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| First interview – at beginning of study (90 minutes) | Standardized open-ended interview | • Explain study and sign informed consent  
                                          • Ask prepared questions on participant background, goals for teaching, etc.  
                                          • CTS task interview to determine participant’s conceptions of teaching science |
| Second interview – after first observation (30 to 60 minutes) | Standardized open-ended interview and/or interview guide | Probe teacher practices for rationale for instruction and preferred teaching techniques |
| Third interview – after second observation (30 minutes) | Interview guide | Probe teacher practices for rationale for instruction and preferred teaching techniques |
| Fourth interview – after third observation (30 minutes) | Interview guide | Probe teacher practices for rationale for instruction and preferred teaching techniques |
| Final interview – after last observation (30 to 60 minutes) | Interview guide | Probe teacher practices for rationale for instruction and preferred teaching techniques |
The standardized open-ended interview was used for the first interview and exact interview questions were included so that the study could be duplicated. The six participants were asked the same questions and their responses were compared (Patton, 2002). The initial interview (Table 3-1) lasting approximately 90 minutes was scheduled at the teacher’s convenience, before the beginning of a new teaching unit. It included prepared questions on participant’s background, goals for teaching science and other topics as well as a modified version of Hewson & Hewson’s Task for Identifying Conceptions of Teaching Science (1989).

The second interview (Table 3-1) scheduled after the first observation, was used to gather more information regarding participants’ conceptions of teaching science and their orientations to teaching science as well as probing for information about teacher practices while seeking clarifications from the earlier interview or from observations.

Three shorter interviews (Table 3-1) using interview guides were conducted after each observation to probe teachers about their practices as it related to the participants’ rationale for instruction and preferred teaching techniques. Interview guides were developed for the post-observation interviews to provide a framework of topics or subject areas that allowed the interviewer to freely probe interesting statements, explore diverging avenues of information, and ask questions that clarified instances viewed during observation.

To focus the topics being asked and elicit clear responses to each question, the researcher developed a clear set of interview questions (Appendices B through D), using special terms or acronyms employed by participants in a particular setting, the language of the participants, and avoiding the use of labels to describe programs or events (Patton, 2002). The reviewer asked secondary science teacher participants a range of questions from their academic background, school demographics, experiences, behaviors, and knowledge, to those relating to teacher’s
opinions, values, feelings, and observations. Patton (2002) suggested that questions be sequenced starting with those about present behaviors, activities, and experiences designed to encourage the respondent to answer in greater detail. After eliciting an experience, the researcher asked the interviewee what his/her feelings or opinions were about the experience to allow them to fully describe the phenomena. As advised by Patton (2002), knowledge questions were asked as follow-up information to minimize threatening participants. Also there were a minimum of background and interview questions to avoid boring respondents or making them uncomfortable. Utilizing all of Patton’s (2002) suggestions for interviews resulted in extensive data.

**Task for Identifying Conceptions of Teaching Science**

Hewson and Hewson (1989) felt that teacher thinking about teaching students and selecting content influence the way that they choose to teach. To discover participant’s conceptions of teaching science they developed a series of teaching and learning scenarios tailored for specific science subjects. Subsequently they asked thirty teachers examine each scenario to determine whether they felt teaching was occurring within each of the scenarios (Hewson & Hewson, 1989). The scenarios, Hewson and Hewson’s Task for Identifying Conceptions of Teaching Science together with probing questions, used to elicit teacher’s choices were designed for use within an interview format to determine a science teacher’s initial CTS.

The task protocol with variations for physics, chemistry, and earth/space science, (Appendix F) consisted of a set of ten scenarios depicting instances, non-instances, and ambiguous instances of science teaching and learning. The scenarios gave the participant a context for their responses which was practical. In addition, it required them to focus only on instances of science teaching in a classroom (Hewson & Hewson, 1989). Participants determined
what is or is not teaching and learning and gave their reasons for their stance based on three questions:

- In your view, is there science teaching happening here?
- If you cannot tell, what else would you need to know in order to be able to tell? What would this information tell you? Please give reasons for your answer.
- If you answered ‘yes’ or ‘no’, what tells you that this is the case? Please give reasons for your answer” (Hewson & Hewson, 1989, p. 198).

The responses participants made to the task protocol assisted the researcher in determining their conceptions for teaching science. All responses were audiotaped.

Hewson and Hewson’s (1989) Task for Identifying Conceptions of Science had several desirable characteristics for my study. First, by providing scenarios which give instances and non-instances of science teaching, it provided a realistic structure for participant responses. Second, since the scenarios were specifically of science teaching, this constrained the participant to focus unambiguously on science teaching instead of management or other prevalent issues in the classroom. Third, the scenarios did not specify what was important or necessary to attend to but left this decision up to the respondent. Finally, using an interview allowed participants to have more thoughtful answers that reflected their ideas and they could revise earlier statements if desired (Hewson & Hewson, 1989).

There are some limitations of the Task for Identifying Conceptions of Science (Hewson & Hewson, 1989). The CTS task addresses teacher’s beliefs about teaching science but not what value participants place on them. The ambiguity of each task varies and allows each participant to construct meaning of each task in their own way. Asking for participants to explain the reasons for their answers only presents teacher thinking about an instructional event, not how they act within a classroom (Hewson et al., 1995). Due to these limitations, Hewson (1989) suggested observing the teaching of participants in addition to the researcher’s administration of
the task. During the first or, in two cases, second interview, I used Hewson and Hewson’s (1989) Task for Identifying Conceptions of Teaching Science. Each of the six beginning secondary science teachers read the ten scenarios and responded to each scenario based on the above-mentioned three questions. All responses were audiotaped for later analysis and were used to develop a concept map and written summary of each participant’s conceptions of teaching science.

Observations

Observation was used to examine the classroom setting of each participant as well as teacher-student and student-student interactions to provide insight into determining each secondary science teachers’ actual instructional techniques and to observe their enacted rationale for science instruction. Some advantages of direct observation included allowing the researcher to better understand and catch the context of classroom interactions, see things that might be missed by the participants or they would be unwilling to share during interviews, and to give the researcher personal experience with the classroom setting (Patton, 2002). This was important to this research because it helped the researcher determine each secondary science teacher’s orientation to teaching science and conception of teaching science.

When observation is used for research purposes, it must meet four conditions, that is, 1) serve a research purpose, 2) be deliberately planned, 3) be systematically recorded and 4) be subjected to checks to determine that it meets standards for validity and reliability (Merriam, 1998). The observer needed training and mental preparation for systematic observation. One of the most important skills was to write descriptively. Observation was used to provide a check on other data collection, to see things participants may not notice, to provide the context of a situation and specific incidents, as well as noting things a subject may not want to report on (Merriam, 1998).
Five dimensions of observational methods determine how the researcher will conduct fieldwork. Each dimension of fieldwork, that is, the role of observer(s), type of perspective, who will observe, how much disclosure about the study will be shared, how many observations, and their focus is arranged on a continuum demonstrating the variations possible in observing participants in a study and the researcher needs to decide on each dimension (Patton, 2002). This study required the observer to be an onlooker in the classroom, to scrutinize the actual events of instruction. The researcher was an observer, giving each participant full disclosure of the aims of the research by fully explaining the study prior to observation and allowing the participant to comment on researcher observations during subsequent interviews. Observations were conducted in the participants’ classes, during the fall or early in the spring semester of the first year of their teaching depending on when the participant started a new science teaching unit. Time frames for observations were determined by teacher schedule and availability but occurred during the first week of a new teaching unit. Due to the difficulty of finding teachers for the study, issues that were addressed in the former section entitled “Gaining access”; all new teachers were interviewed and observed late in the first semester or early in the second semester, allowing them more time to negotiate classroom management issues and focus on their subject matter instruction.

The school setting was observed by describing the physical environment of the school and classroom in rich detail. This was accomplished by the researcher spending time before or after a particular interview or observation, or in some cases prior to or after the school day writing down observations of the classroom and school. All participants eagerly showed me their school and classroom, and allowed ample time for both written and audiotaped observations. Patton (2002) proposed the social environment of the classroom was best described by looking at patterns of
student organization into groups and subgroups, frequency and quality of teacher-student and student-student interactions, and decision-making patterns within the learning setting and this was accomplished by the researcher. He further suggested that field workers pay close attention to informal interactions and unplanned activities to help clarify phenomena happening in each classroom. These interactions and activities were not only observed but also incorporated as questions that were asked of participants during their subsequent interviews to gain a clear understanding of the interactions and activities and participants beliefs about them.

Data Analysis

There were two types of data analysis which occurred. First, the Task for Determining Conceptions of Teaching Science (Hewson & Hewson, 1989) was analyzed using the analysis scheme the authors devised with biology and chemistry scenarios developed by the authors and earth/space science scenarios developed by the researcher (see Appendix E). Second, all other interview and observation data was analyzed using thematic network analysis (Attride-Stirling, 2001).

Analysis of CTS Task Data

During the first interview for four participants and the second interview for two of the participants, the CTS task was performed. Data from the task was analyzed using the analysis scheme proposed by Hewson and Hewson (1989) modified by Attride-Stirling’s (2001) thematic network:

1. The task transcript was read and all statements by each respondent which explicated their view recorded. Specific words of the respondent were used when possible for accuracy.

2. Every respondent statement was placed into one of seven categories that were suggested by the data, modifying the six categories that Hewson and Hewson (1989) suggested:

   - **Teacher Characteristics**: beliefs participants hold about characteristics that determine an individual’s teaching
• Teaching: beliefs participants hold about teaching
• Learning: beliefs participants hold about learning
• Learner Characteristics: beliefs participants hold about characteristics that determine an individual’s learning
• Conditions for Instruction: what a participant believes are necessary conditions in order to teach effectively
• Preferred Instructional Techniques: a teacher’s strategies, techniques, methods, and practices for successful science instruction
• Conception of Science: a participant’s conception of any of the components of teaching science, that is, nature of science, learning, learner characteristics, rationale for instruction or preferred instructional techniques (Hewson & Hewson, 1989).

3. Categories for “Teacher characteristics” and “Teaching” were added from analyzing the data. The category “Rationale for instruction” was renamed to be “Conditions for instruction”, combining two categories: “Conditions for teaching” and “Conditions for learning.” The category “Nature of Science” was combined with “Conception of science” as there were few if any statements which fell in this category. Any statement was placed into as many categories as it applied to.

4. Statements that seemed to concern similar features were grouped together and written in a single sentence summary.

5. These summaries were used to summarize the respondent’s conception of teaching science (Hewson & Hewson, 1989).

6. The researcher constructed concept maps of each participant’s conceptions of teaching science to guide in writing the summaries for clarity and to tie the CTS analysis with the thematic network analysis technique.

Analysis of Interview and Observation Data

Analysis of interview and observation data other than that collected by the Task for Determining Conceptions of Teaching Science (Hewson & Hewson, 1989) were accomplished using thematic analysis (Attride-Stirling, 2001). This type of analysis attempts to interpret text to find the themes within it at three different levels, basic, organizing, and global. After the three thematic levels are extracted from the data they are put into a concept web or thematic network which is described and summarized in the report (Attride-Stirling, 2001). The goal of thematic
networks is to produce concept maps which summarize the main themes within text being analyzed. Thematic networks were used as an analytic tool because they graphically illustrate relationships among themes within the research. Although thematic networks were relatively a new analytic tool, it was used for both critical ethnographic research about breastfeeding (Dykes, 2005), and a descriptive qualitative study that focused on identifying critical issues in rural hospitals in Australia (Kenny & Duckett, 2004).

To begin the analysis, all interviews and observations were carefully transcribed to text. To aid in the transcription, participants were asked during the first interview to read a fifteen to twenty minute text that was used to train voice recognition software to their particular voice. All participants were willing to perform this task and further wore a headset with attached microphone which recorded their responses to all questions into a digital recorder. A second audio recorder with directional microphone also recorded researcher questions and participant responses.

All data called .wav files from the digital recorder were copied onto the researcher’s computer where they underwent analysis. The researcher used Dragon Naturally Speaking 7.0 voice recognition software and a Sony SX25 digital recorder to record participant speech for a high level of compatibility as was suggested by the software manufacturer. The text generated by the voice recognition software was then edited by the researcher using an audio transcriber and the backup audiotape. This allowed faster transcription of the interview data, in most cases cutting transcription time in half.

Observation was made using a special device called an IO2 pen which allowed the researcher to write observations on a digitized pad in regular ink. The writing was also recorded digitally in the pen and was uploaded into the computer where a software program translated the
handwriting into text using optical character recognition (OCR) software. The text that was generated by the OCR software was then checked against the handwritten data on the digitized pad and edited for correctness. Using the IO2 pen allowed the researcher to unobtrusively observe classroom interactions and avoid transcription errors associated with writing observations and then later transcribing by providing a recording and transcription environment within one device.

Next, the text was examined and coded and a codebook developed. Codes were examined and deconstructed into words and phrases under a basic theme. As each piece of data was examined it was compared against the initial themes of the last piece of data (Merriam, 1998). The basic theme was the lowest theme and came directly from the text found in observations, interviews, and other transcribed data. Next, the basic themes were grouped together into a middle order category called the organizing theme. Its role was to both organize the basic themes and “enhance the meaning and significance of a broader theme” (Attride-Stirling, 2001, p. 389).

Third, global themes, the categories which made a statement about the data were formed from gathering together group sets of organizing themes. Global themes “present an argument, or a position or an assertion about a given issue or reality” (p. 389) and made sense of all the lower-level themes (Attride-Stirling, 2001). Developing global themes paralleled Merriam’s (1998) explanation of the process of grouping categories into larger headings thereby identifying a small number of manageable themes.

At this point, a thematic network was developed using symbols, arrows and text to illustrate each global theme and its corresponding organizing and basic themes. One thematic network was created for each global theme. Once the thematic network or networks were
constructed, the researcher described the contents of each network using text segments to illustrate the description and underlying patterns began to appear (Attride-Stirling, 2001).

The thematic networks were used as the researcher re-read the data within the context of the three levels of theme. Summarization of the thematic network(s) brought out principle themes and patterns in the data. The researcher brought together deductions used in summarizing all networks and interprets patterns that had been illuminated in the data (Attride-Stirling, 2001).

The findings from this research were a case study defined as “an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process or a social unit” (Merriam, 1998, p. 27). The case study design seemed appropriate due to the nature of research questions asked. This topic was suited to a case study as it was particular, or focused on the phenomenon of beginning secondary science teachers’ conceptions of teaching science and orientations to teaching science. Case studies were descriptive and findings provided rich, thick description of the situation under study. They illuminated the understanding of those who read the study, possibly triggering discovery of new meaning, extending experience, or confirming that which is already known (Merriam, 1998). A complete analysis of the data in each case study should provide a thick description of a group of beginning secondary science teachers’ conceptions of and orientations toward teaching science as they progress through the beginning of their first year teaching.

**Subjectivity Statement**

Qualitative research demands that the researcher is the instrument in the study being conducted (Creswell, 2003). Thus, because data collection and analysis are potentially influenced by researcher bias, the researcher must explicate any experiences and beliefs that could affect the study and the interpretation of the findings.
I graduated from a university teacher education program as a secondary science teacher and have a strong background in chemistry, geology, astronomy and physical science. I taught general science, physical science, chemistry 1, honors chemistry, chemistry 2, and integrated science for seven years prior to commencing doctoral studies. During my doctoral studies I instructed pre-service elementary teachers in science methods, co-taught a graduate course on the foundations of elementary science and presented research on teaching, using educational technology in science, and elementary science education at regional and national conferences.

Based on my background, I felt a strong connection to the study participants having shared both their science content focus and many of the experiences they encountered as first year teachers. This allowed me to quickly develop rapport with all of the participants in the study but may have caused participants to assume that I knew and understood their perspective in interviews without making it explicit.

I became interested in orientations to teaching science as well as conceptions of teaching science as a construct of teacher thinking while studying pedagogical content knowledge for my comprehensive exams. As a researcher, one of my interests is the lack of research into beginning science teachers thinking about instructional decisions on teaching science. While there have been studies on pre-service and seasoned in-service elementary and secondary teachers, there is a paucity of research on first year unsupervised teachers, their thoughts about preferred instructional styles and their rationale for teaching science.

One of my hardest tasks during the analysis of the data and writing of this document was to not make instant judgments of participant’s conceptions of and orientations to science but to rather rely on the data to illustrate their particular CTS or OTS. To separate myself as much as possible from the data, I used the following strategies:
transcribed the interview data with pauses, exact terminology, and vocal inflections to ensure accurate transcription,

- read and analyzed the data and wrote first draft of manuscript,
- asked participants to member check their data for accuracy,
- re-read and re-analyzed the data before making modifications,
- asked independent reviewers to proofread the manuscript,
- read data and checked analysis of data a third time prior to final revision of the manuscript.

It is my hope that these strategies assisted me in removing as many subjective judgments as humanly possible.

**Validity**

It is crucial for the validity of a research project to ensure that a true picture of the phenomena under study is honestly and fully reported. This is achieved through participant observation, in-depth interviewing, detailed description and case studies (Patton, 2002). Validity in qualitative research is checking to see whether the findings of the study are accurate. To accomplish this task the researcher triangulated several different sources of data, namely observation and interviews, used member-checking to ensure accuracy of the findings, clarified the bias she brought to the study, and used rich, thick description to elucidate her findings (Creswell, 2003).

**Credibility**

As the instrument of quantitative research, the credibility of any study “hinges to a great extent on the skill, competence, and rigor of the person doing fieldwork—as well as things going on in a person’s life that might prove a distraction” (Patton, 2002, p. 14). The researcher has
hopefully made her/his biases explicit and has been open to data that supported more than one explanation of phenomena for the research to be considered credible (Glesne, 1999).

Additionally the researcher has eight years of education and training as a researcher. She has conducted action research in her science classroom during a three-year period and reported the research. During the four years preceding this study she has been observer, interviewer, and analyst in several studies. One study dealt with elementary education while two others investigated educational technology use in science methods classrooms. Each study resulted in presentation of the data and several articles written from their findings.

Additionally rigor requires the researcher to look for data which support alternative explanations of the phenomenon he/she is investigating. As Patton (2002) states, “Failing to find strong supporting evidence for alternative ways of representing the data or contrary explanations helps increase confidence in the original, principal explanation you generated” (p. 553).

**Trustworthiness**

Trustworthiness or rigor of the study could be adversely affected by observer bias, that is, certain characteristics of observers that could possibly bias what they observe. To prevent this, the researcher observed and interviewed each participant five times at respective school sites. These interviews and observations in addition to analytical notes generated large amounts of data. Finally the researcher wrote detailed field notes which included reflections on my subjectivity (Wallen & Fraenkel, 2001).
CHAPTER 4
SETTING THE STAGE: INTRODUCING THE TEACHERS AND EXAMINING THEIR
CONCEPTIONS OF AND ORIENTATIONS TO TEACHING SCIENCE

Background

Geertz (1973) believed thick description provided the foundation for explaining the statements and actions of participants being observed and interviewed. Qualitative analysis and reporting requires this descriptive technique in order to not “obscure most of what we need to comprehend a particular event, ritual, custom, idea, or whatever is insinuated as background information” (Geertz, 1973, p. 9) when reporting on data. Patton (2002) envisioned the background for analysis as the “setting being described” (p. 137). In this exploratory multi-case study I examined beginning secondary science teachers’ conceptions of and orientations to teaching science. This chapter introduces the six teachers I chose for my study and the setting of their schools and classes thereby setting the stage for examining each beginning teacher’s conceptions of teaching science followed by their orientation to teaching science within their defined role as new science teacher in each section.

My study was exploratory due to the small number of participants and the inequality of participants in each of my two categories, namely one participant traditionally certified, and five in the process of becoming alternatively certified. The exploratory nature of the study allowed me to describe my participants and look at their differences and similarities without generalizing from these descriptions. For each individual I studied I attempted to give the school context, a summary of their conceptions of teaching science CTS, and a summary of their OTS. This permits the reader to examine the different science teaching conceptions and orientations to teaching science held by these teachers and to draw their own inferences.

A diagram was used to present each teacher’s conception of teaching science, and their orientation to science. It was used as a visual aid to viewing the beginning teacher’s CTS and
CTS. The development of each teacher’s CTS and OTS is an active process which takes time and reflection to develop and is not in the scope of this study. I was only able to spend a small period of time with each participant, observing a week in the life of each science teacher in only a few different classes. Most of my participants taught more than one subject but to better observe their teaching strategies and how these supported their conceptions of teaching I chose to observe them in one subject over different classes. This provided a snapshot of their CTS and OTS at a point in time during their first year of teaching.

These beginning secondary science teachers were my primary unit of analysis so I focused on the case studies of the six individuals in their various settings. Each of the teachers was unique in their background and prior experiences and each took an individual path to teaching. The introduction, school and classroom setting, conception of and orientation to teaching science for each participant are presented below.

**Patrick**

**Introduction and School Setting**

Patrick was in his late twenties, working toward alternative certification and a first year secondary science teacher at a local rural high school in the north corner of County One. He had a bachelor’s degree in sports medicine from a university in the northeast United States and took two education classes as an undergraduate in addition to his science courses. For a few years after attaining his degree Patrick was a fitness coach for his alma mater and later a director of sports and education for a prestigious university in his area for a few years. As part of his coaching duties Patrick had to teach undergraduate weight lifting and exercise science classes for two semesters. During his term as a director, Patrick started teaching physical education classes part-time and found he enjoyed it. This led to his working two days a week at a private school instructing elementary pupils in science activities.
Patrick started a master’s degree in education but had to cancel classes and relocate to the south when his wife was accepted as a doctoral student at a large university in Florida. I asked Patrick when he decided to become a teacher:

“Well I [always] knew I was going the teaching route. I just did not know this early. I was planning on getting my master’s first and then do some student teaching, whatever else needed to be done. But upon moving down here it was basically the only thing open to me with my field” (PI1:150-153).

Patrick searched for a coaching job at the local university but found these positions filled by local graduates. After being told teachers were desperately needed he decided to apply, and took and passed all of the Florida teacher subject area exams including those certifying him to teach secondary biology and grades five through nine general science courses.

Patrick’s school was located in the town of Country Meadows in the northeast section of County One. Country Meadows has a population of roughly 6800 people, and all the amenities of a small town including a picturesque Main Street. Spring High School educates students in grades nine through twelve and has 1,288 students who are predominantly white (74%). The next largest student ethnicity is African-American (19%) and there is a small Hispanic and multiracial population (5% and 1% respectively). Twenty-five percent of the students are being provided free or reduced lunches. Sixteen percent of the teachers were in their beginning year of teaching and teacher education levels range from bachelor’s to a small number of teachers who possess doctorate degrees.

**Classroom Setting**

Patrick’s high school was a ‘60s style one story building of cinder block construction. There were two main buildings and five long separate buildings containing classrooms radiating out from them attached by covered breezeways and walkways. The next to the last building was
the science wing with Patrick’s classroom at the end of the wing. The cream colored walls of his classroom were filled with science posters and paraphernalia. Against the wall right by the door he had a periodic table of the elements and several posters, one of which had a title which proclaimed “no sweat!” about physical training and electrolytes and minerals that you lose in your body when exercising.

Three student-made posters on mitosis hung on the side walls and a large poster detailing research presented at a conference suspended on the front wall to the left. There were jars of pickled brains and other types of organs of the body on a bookcase to the right upon entering the room. Books on anatomy and physiology and the skull of a bison were placed on the shelves as well as a TV to the left. An overhead projector was placed on a rolling cart on the right. He had a large chart of a skeleton on the wall and a mounted skeleton against the rear wall and both appeared well used. Patrick’s desk was up front, mounted on a dais and also used as a demonstration table. A stool sat by the desk and a chair was placed behind it.

Another desk sat to the left of the mounted one and held his computer monitor, mouse, and keyboard as well as a mounted microscope display hooked up to the LCD projector on a cart in the middle of the room. The student desks in his classroom were aligned in rows pointed toward the dry erase board mounted behind his demonstration desk on the dais. The back and side walls of the classroom had sinks with running water mounted into a slate tabletop that runs the length of both of the walls. Stools were placed below the tabletops at intervals.

The back wall had several mounted cabinets where science equipment was stored. At the rear of the room in the corner by a window emergency equipment was mounted including goggles, a fire blanket, a shower, an eyewash station, and a paper towel dispenser. There was an area rug mounted on the floor of the room with a 2-foot area between the rug and wall all around
the room. The room looked worn but organized, neat and clean. Additionally there were four aquariums on a long table on the side of the room.

Patrick’s students appeared to be in their late teens and enrolled in grades ten to twelve as this was an elective science course. He shared with me that many students took this course as a third science course because they were interested in the body or planned to continue studies in medicine of some kind. The classes I observed had between twenty and twenty-four students in each.

**Conception for Teaching Science**

Hewson and Hewson (1988) discussed an appropriate conception of teaching science wherein science teachers should be convinced that science was a particular type of teaching different from others and had its own set of tasks and activities geared to help specific students learn a specific content. They felt that teachers needed to know their students and understand different ways to teach for concept understanding (Hewson & Hewson, 1988). Patrick had a teacher-centered conception for teaching science which is focused on the teacher as authority figure in the learning process. Figure 4-1 consists of his conceptions of the teacher and teaching, specific instructional strategies, science, learning and the learner, and various conditions for instruction.

**Teachers and teaching**

Patrick saw the teacher as the source of knowledge and believed a teacher needed formal training and experience in order to teach effectively. He felt strongly that someone with advanced education could teach at any level as relates to his comment about a teacher lecturing to a group of first-graders that “a college professor can do it. . . I’ve seen it done” (PCI: 164-165). Teaching was described by him as asking a question, leading discussion and using specific
Figure 4-1. Patrick’s Conception of Teaching Science.
strategies to teach. Patrick believed it was the teacher’s job to lead students in learning. He stated: “you’re posing a question and hopefully they will answer it” (PCI: 212-213).

Teaching was about outcomes in Patrick’s view and “you want [students] to think about it and either look it up or recall information that you’ve taught” (PCI: 214-215). Patrick felt that teaching “puts something in front of you and asks a question.” He viewed teaching and learning both as going on when “you’re asking what’s happening next so you know what’s happened prior” (PCI: 210-211). Patrick did not use inquiry but preferred a more guided approach or “a little more lead to get the questions rolling” (PCI: 51). He believed students had little prior knowledge and felt he needed to prepare them for a topic (PCI: 194-195). Additionally Patrick felt students could learn on their own “trying to teach themselves” but believed this was not teaching (PCI: 251). Patrick thought learning could occur from students viewing media if it was good quality (PCI: 105-106).

**Instructional strategies**

Patrick believed in using teaching strategies because there was “learning going on just depending on what you’re using to present the material” (PCI: 185-186). He felt visual aids were the best teaching strategy for real learning and stated that “students need “some sort of visual aid just to show where it is happening” (PCI: 180-181). In Patrick’s classroom, lecturing was used extensively but there needed to be some sort of visual aid to help the student process the material.

“[Students] might not be able to visualize it without some other aid or whether I say you know, open to page hundred and two in your book. Follow along in the diagram. I mean if that’s all you have, that’s all you have but I think more the merrier” (PCI: 187-190).

Because of these beliefs all of his beginning lessons on a topic were done on PowerPoint and presented to students with film clips and diagrams from the book. Patrick also used
worksheets in his classroom to set up the learning or “do a little something before hand or even just a worksheet” (PCI: 59). These were followed up by activities where the students produced something (a human outline with the muscles sketched in and labeled, a poster of the articulated skeleton of a rodent or other prey creature from an owl pellet) in order to practice the knowledge that they learned from the original lectures.

**Conceptions of science**

Patrick saw the learning of science as a progression of the content, and viewed learning as being built upon prior knowledge given by the teacher (PCI: 194-195). When looking at a question of particular knowledge a student was learning on digestion he viewed it in terms of what had been already covered “you know the acids in the stomach and stuff like that before we even got to digestion” (PCI:182-183).

Science content was extremely important to Patrick. In his anatomy and physiology class it was essential that his students know every bone of the human body and he spent much time during the first semester ensuring they had learned this information. It baffled him that it took them so long to learn the content. Patrick’s concept of the nature of science dealt with science as theory-laden and human-constructed. In the movie *Medicine Man* he viewed science as being derailed by economic development and talked about “the ups and downs of you know, global trade encroaching in on someone just trying to do research” (PCI:125-126).

**Learning and learners**

Learning for Patrick was an active experience where students performed tasks in order to learn about the world. He envisioned students learning by themselves, from their peers, and by teachers and others but always in a task-oriented environment. In a particular scenario he saw learning happening between students “whether they’re just adding calories together or fats or
transfats or whatever, they are learning about the foods that they’re trying to do the calculations on” (PCI:150-152). Later he expressed his feelings about task-oriented learning by his statement:

“yeah, they’re learning. They have to mix chemicals together, compounds together an, they’re reading, they’re following directions, they’re, they’re going to have a product at the end that’s different from what they started with, the different products they started with” (PCI: 257-260).

He separated learning from teaching in that he thought a teacher was needed for teaching. Patrick posited “there is learning. I don’t know if there’s teaching going on. The student’s trying to attempt to understand something” (PCI: 251-252).

Patrick visualized learners as needing to be motivated to learn especially away from the teacher. He viewed them as having little prior knowledge and felt the need for students to have specific tasks assigned to them in order to promote the right conditions for learning. He stated that “they have to have done questions in the book by then just to get themselves orientated” (PCI: 194-195). Additionally he considered that a student’s age determined whether learning could be accomplished (PCI: 49-50).

**Conditions for instruction**

A condition for instruction Patrick talked about for teaching to be accomplished was that the materials be reliable, that is, from an accepted educational source or approved by the teacher. He worried that students when watching a program away from school were “probably going to get a lot of information from it. It is just, I don’t [know] what type of information they’re getting from it” (PCI: 131-133). His major concerns about the information students were receiving was its reliability and that it be unbiased or present both sides to allow students to have a balanced understanding (PCI: 106-107).
Orientation to Teaching Science

A teacher’s orientation to teaching science (OTS) stems from a teacher’s “knowledge and beliefs about the purposes and goals for teaching science at a particular grade level” says Magnusson, Krajcik, and Borko (1999). Patrick had a combination academic rigor/didactic orientation to teaching science (Figure 4-2) that was driven by his goals for his students and learner characteristics. His OTS was also reflected in his rationale for teaching, that is, how he planned for lessons and his scheme of assessment and was evidenced by his teaching style and strategies for teaching.

Goals for teaching

An academic rigor orientation was proposed by Lantz and Kass (1987) and has as its goal to represent a particular body of knowledge. This was in line with Patrick’s primary science goal for his students as he wanted them to gain content knowledge or as he stated, “just knowing the subject material” (PI: 349) of anatomy and physiology. For Patrick, students needed to know the terminology and have knowledge of the subject matter: “I mean they have to know where these muscles are and the names of them and you know the proper names too” (PI: 472-474). He felt strongly that they needed to “visualize” the structure and systems of the body and the proper placement and had his students spend a large part of class in demonstrations and laboratory learning these structures thoroughly.

Concept knowledge for Patrick was biology literacy. He felt that students need “just a better understanding of themselves and I think it will help them” (PI1: 390) and comments “It is good to know what’s wrong with you” and to be able to “apply it too.” He spent part of class time in what he calls “going to the clinic” to develop his student’s knowledge of illness. “You have to at least understand what’s going on with your body . . . to ask some of the questions” (PI3: 165-166) he posited.
Figure 4-2. Patrick’s Orientation to Teaching Science.

Patrick also wanted students to explore science careers. He designed an assignment for students to learn about a career field and answer questions on it concerning the “schooling, pay
scale, clubs and organizations you’d have to belong to, societies, and that actually opened the eyes of a lot of kids” (PI1: 370-374). Patrick had an internship in college where he was able to work in a career field he was interested in and found that it was not for him. Patrick wanted this knowledge for his students.

Two general goals for Patrick required that students have academic preparation, “reach my expectations”, and gain technology skills. He wanted to prepare his students for college and felt that he needed to get them “using audiovisual stuff, technology stuff, like working in PowerPoint’s and becoming familiar with PowerPoint and also you know be able to pull stuff from reference books and asking questions” (PI3: 7-9).

**Science curriculum**

Patrick was concerned that his students understand the science curriculum and be prepared academically for anatomy and physiology in college. Starting at the beginning of the year he taught orientations or as he commented “just learning root words and orientations of the body and the terminology (PI2: 309-311). Later in the year systems of the body were taught (PI2: 315). He tried to sequence instruction and introduce concepts when studying those systems of the body (PI3: 115). The textbook was good, Patrick felt but “too watered down” (PI1: 484). He wanted a textbook which had more “rigor” (PI1: 486).

**School context**

Patrick taught in a rural public school in County One. He taught five periods of anatomy and physiology but was looking forward to the next year where he would be allowed to teach Advanced Placement anatomy and physiology.

Patrick had issues with the facilities in his classroom. He had a rug on his floor that made it difficult to perform science experiments and laboratory facilities for his students. “I mean I would really love to have benches in here instead of these desks but you know you work with
what you got” (PI1: 372-373) he stated. Another problem he faced was technology availability.

Patrick had problems getting equipment ordered from the media center at the times he needed it (PI4: 9-11). A lack of materials made it hard for him to order dissection supplies. When discussing the size of groups for activities he commented “ideally you could do this in groups of two but I just don’t have enough paper” (PI2: 159-160).

Other issues dealt with time. “People say ‘Oh you’re first year is always the worst’ because you’re making everything from scratch. And that’s true…worksheets and dittos and stuff I’ve been making from scratch and it is a lot of time. It is a lot of effort” (PI2: 349-353). Another factor of school context Patrick managed were classroom visits by the principal on a regular basis. This is also district policy for all public schools.

**Learner characteristics**

Patrick taught anatomy and physiology, an option class for high school juniors and seniors and saw his students as having high ability. “They’re all bright kids – some of them I have are bored with class – I bet there’s everybody in those classes” (PI2: 37-38) he states, continuing, “I’ve got kids who are taking honors history, I got kids are in remedial math, you know AP science and eighth grade English classes” (PI2: 38-40). Patrick felt his students were attentive and motivated commenting “for the most part I mean it is a pretty good group” (AI3: 176).

Student concept understanding was positively viewed by Patrick in his classes. “They understand it. I know they understand it because of some of the questions I get” (AI3: 164) but explaining his testing concerns he continued “It all goes out the window for testing sometimes but they, I think for the most part they get it” (PI3: 166-167).

Patrick tried to touch on multiple learning styles in his lecture strategy stating, “I read it through so they hear it, I hear it, and I see it. Then they and I kind of try to break each other
Grouping students by ability was a problem in his class as he did not trust that his students would fairly apportion work. “I try to but sometimes I find with some of the group projects you get the best student doing all the work”, (PI2: 140-141) he muses.

**Rationale for instruction**

Lantz and Kass (1987) believed that a teacher’s background, curriculum materials, and teaching situation mediated a teacher’s orientation to teaching science, what they called their functional paradigms and was evidenced in their classroom practice. Patrick took the curriculum he was given and mediated it with his academic background to determine what he taught and how he sequenced instruction.

His lesson planning was directed toward teaching the concepts of anatomy and physiology and covering the material. As Patrick commented, “all I can hope for is just to hopefully get a good guideline that let’s me make sure I cover all the material that’s in there” (PI2: 464-465). The textbook was not rigorous enough for Patrick. He felt “its kind of a watered down version” (PI1: 485) of the college text and wanted to change to a different textbook next year. He did not like the “depth of the text” and felt that students should know the actual names and functions of all bones, muscles, and systems of the body as well as their functions and the diseases associated with them.

Patrick’s assessment of student learning focused on homework, labs, projects and tests making up student’s grades. Testing was for him “the tried and true method of learning” and getting a good grade on the test was going to “definitely depend on how much they retain you know from our notes and the review and what we’ve done” (PI3: 240-242). Patrick used
homework and extra credit to help struggling students “get a higher grade in class” as he felt that “students who are getting A’s on tests usually blow off homework assignments” (PI2: 415-416).

**Instructional strategies**

Patrick used many teaching strategies but relied heavily on lecture, note taking, and technology placing a “high value on pedagogical efficiency” (Lentz & Kass, 1987). He used a focal space in the front of the room filled with charts and a hanging skeleton to give students additional information when they worked on assignments and projects. “Well they always look up here for answers in general so I try to fill the space with much of the topic” (PI2: 247-248). The PowerPoint presentations he used always had a chart or diagram.

His activities during the time I observed consisted of students working on charts of the body musculature and crossword puzzles, and he liked to use and have students create models or charts of various science concepts. Grouping in his class was assigned and changed each semester and there were a “set of rules.” He did not care “what [students] have done or what has been done in the past but this is why this is so” (PI2: 106-108) as he related to me concerning his rules.

Patrick used questioning as a teaching strategy. “I get excited about the subject material and sometime I find we can waste a good twenty minutes of class just answering questions that I posed.” (PI1: 328-330) He felt that questions could be used to keep students on task “just to let them know that I’m watching them” (PI2: 179-180) as well as to help them apply the material. Worksheets were used on a weekly basis as a “reinforcement of the terms” presented in his lectures and to act as a review of the material.

“I try to do a project with each unit too whether it be a summary on something, a short paper on something” Patrick stated, and was very rigorous in his requirements and grading. One project, dissecting owl pellets, was performed during the unit on the skeleton and he had students
articulate the bones they found into a skeleton of the rodent to give them practice in naming and placing the bones in the proper place.

His teaching style was strongly lecture driven. “What I do is I lecture”, he avers, and expects students to take copious notes having them “write them down or I copy them up and they have to follow along and I delete words so they have to pay attention” (PI1: 251-253). Patrick was the authority figure stating that “I do not like to be their friend” (PI2: 42) using proximity to keep student’s focus on him and the lesson at hand. The crux of his teaching style was to “go straight through the aspects of anatomy and physiology and we start small and get big” (PI2: 306-307). He stressed the “small to big” philosophy several times in our conversations. Patrick believed strongly that he should tailor the information, not teaching out of the book but teaching “the information that they need to know.” His teaching style was very technology-oriented, using PowerPoint slides to lecture with, putting class notes on his web site for students to download and using video to “try to give [the material] more dimensions than just looking at words on a projector” (PI3: 59-60).

Meredith

Introduction and School Setting

Meredith, in her early twenties, was in her first year teaching secondary science at River Middle/High School in County One. She had a bachelor’s degree in biology/earth science education. During her internship she taught anatomy and physiology and biology in a secondary classroom. She took fifteen hours of sciences for her degree. Meredith also performed some scientific research where she worked with one of the professors conducting an experiment heating up copper molecules to determine if they would move.

When she was in high school Meredith realized she loved science and knew she wanted to do something in this field. At university Meredith majored in biology. She moved to another city
with a different university, started to substitute teach and fell in love with it. At the time she said, “you know, I really like this. I like being able to see them catch things and see them understand” Meredith transferred into the Biology/Earth Science Education program and attained her degree.

River Middle/High School was a rural education center in the small town of Crossroads in the south eastern corner of County One in central Florida. Crossroads had 1,500 residents. From the main road you could see the marquee for the school, the bus barn and sports fields. River Middle/High School educated students in grades six through twelve and had 510 students who are white (62%), African-American (34%), Hispanic (2%) and other ethnicities (2%). There was a large population of students being provided free or reduced lunches (62%). One-third of the teachers at River M/HS were in their beginning year of teaching and teacher education levels range from bachelor’s (50%) to a small number of teachers (3%) who possessed doctorate degrees.

**Classroom Setting**

Meredith’s school building was located six blocks from the sports fields in a quiet area with little traffic. It consisted of a long one story edifice. The room where Meredith teaches was located in the western end of the building. It was a large cinderblock structure having two doors at the rear of the room with counters on three walls. The counter running the entire left wall of the room had four sinks placed every four feet with drawers and cabinets underneath. There were two shelves containing lab manuals and other reference books mounted on the wall in the left rear of the room over the counter. Stacks of text books were piled on the counter between the sinks.

Another counter with sinks, drawers, and cabinets ran across the rear of the room between both doors and had only three sinks. The right wall of the room had another long counter which
stretched along the entire length with no sinks and gas jets mounted on the counter at four foot intervals, and drawers and cabinets below. All wall counters acted as lab stations for the room.

The teacher area in the front of the room was elevated on a semicircular dais one step above the classroom. A fume hood was built in the right front corner of the dais with a portable projector screen next to it. The large teacher desk appeared to be a science demonstration platform with water and gas hookups. A long chalkboard covered the front wall of the classroom. To the right of the chalkboard a bulletin board was mounted.

There were desks with attached chairs in this room set up in rows of four or five desks facing the teacher dais. A mounted metal cabinet on the left wall appeared to hold lab goggles. Stools were scattered around the room in front of the counters. All walls had posters and decoration, including the area above the chalkboard which had a series of pictures. On the left edge of the chalkboard were schedules written in chalk for all classes.

A television and clock were mounted on the left wall above the counters. Stacking trays for student’s homework sat on the left counter of the room. To the right side of the demonstration platform perched a desk holding a desktop computer, monitor and printer. A small student desk was on the left side of the dais against the chalkboard with animal cages containing guinea pigs placed on it.

**Conception for Teaching Science**

Meredith had a student-centered conception of teaching science (Figure 4-3) based on the “need to use instructional strategies which take into account student’s existing conceptions, especially when they conflict with those being taught” (Hewson & Hewson, 1988, p. 610). Her CTS had several parts including her concept of teaching, teaching strategies, science, learning and the learner, and her conditions for instruction.
Facilitating development of students’ understandings about science and changing science-related conceptions

Figure 4-3. Meredith’s Conception of Teaching Science.
Teachers and teaching

Meredith understood that learning must occur for teaching to happen (Fenstermacher, 1986) illustrated by her clarification of the scenario of a professor lecturing first-graders when she states that “there's science teaching being attempted.” On other scenarios though she questioned this belief: “I think they all could be science teaching. . . I just do not know if it would be science learning” (MCI: 126-127).

Meredith viewed teaching as happening in a variety of situations with and without a teacher in front of a typical class and stated “I can see how all of these have been teaching, they’re just different ways of teaching” (MCI: 153-155). She supported inquiry and teaching for conceptual change as evidenced in her statements that a student question “gives the teacher a really good opportunity to answer this question, correct misconceptions of there are any” (MCI: 189-191) and “by doing an activity like that you’re having the kids not only look at different types of organisms but they’re going to be classifying them in some way or another by something that they can observe plus they’re practicing observation skills” (MCI: 26-30).

Meredith believed good teachers “made that personal connection with the students” (MII: 125). She discussed modeling her mentors: “I thought they did a good job for me so obviously they were doing something right” (MII: 118-119). Modeling her former teachers, Meredith kept in touch them, used many of their teaching strategies and borrowed activities.

Instructional strategies

Meredith’s used inquiry and saw it as “sneaking knowledge in because I think that works best especially if kids are initially hesitant to learning anyway” (MCI: 23-24). She viewed teaching strategies as dependent on the age and cognitive level of the child and commented about one scenario involving elementary students that “lecturing probably is not going to work or as much as having then do something like looking at fish and saying what happens when you know
the predators come to eat the fish and then that they can visually see happening” (MCI: 106-109). Meredith used media as a teaching strategy, choosing popular film as a motivator but asking goal-oriented questions. She commented: “it depends on what your goals would be for watching something like that. Like I showed ‘The Little Mermaid’ and at face value … it is a Disney movie but I chose to ask students questions based upon what we were talking about in osmosis and things like that” (MCI: 59-61).

She suggested using diagrams and visuals in teaching and when talking about science vocabulary mentioned that “you could show that relationship and then if they've seen the word, heard the word, than they might have a better chance of being able to produce the word on their own” (MCI: 177-180)

**Conceptions of science**

Meredith was comfortable with science content and saw the importance of scientific terminology. She explained that there was a “difference between academic vocabulary and regular speaking which can be applied lots of different things. There are lots of words that are common used in everyday language. That is different when it comes to science” (MCI: 139-142).

She discussed student misconceptions in discussing a student question that “it gives the teacher a really good opportunity to answer this question, correct misconceptions of there are any or whenever.” (MCI: 189-191).

**Learning and learners**

Meredith constantly asked herself “is this learning?” She viewed students as learning without a teacher at hand: “they’re teaching each other in addition to working it out but I can see how they would be helping each other if one of them did not understand and another one could help out” (MCI: 73-75) but later stated that “it could be [learning]” (MCI: 75-76). Meredith believed questions were an avenue to learning. She posited when looking at students baking
something “what is the difference in a physical and a chemical change? Well it started off as blueberry batter and now it is blueberry muffin. How did it get there? Can you make it go back to blueberry batter from blueberry muffin?” (MCI: 205-208) and stated that teaching and learning could happen “because of the type of question this is.”

Meredith discussed some learner characteristics. She saw student interest and motivation as important when she commented that “because they’ve chosen to watch this they will probably be more receptive to the information there” (MCI: 50-51). Meredith looked at a student’s age and cognitive level when examining teaching and learning. She stated, “[first-graders] might grasp – they probably would not get the terminology – but they might grasp the concept” (MCI: 109-110) and judged other material as “completely appropriate for that class.” She comprehended different learning styles in her explanation that “some students can learn with the teacher standing there giving them information and they’re capable of applying and/or regurgitating” (MCI: 129-131). Meredith showed an understanding of her student’s capabilities by her statement that “if this were hypothetically for my students well how do they know how to spell the words” (MCI: 162-163) and “that’s a lot asking them to remember.”

**Conditions for instruction**

Her conditions for instruction formed the last part of her conception of teaching science. Meredith looked at the quality of media when determining whether to use it for instruction. She commented on the educational value of students watching video at home when she stated “it probably is some type of documentary or educational programming” (MCI: 51-52). She continued: “if this were a documentary type program at least they’re getting true factual information hopefully as opposed to some imagination from someone” (MCI: 66-68). Meredith determined there had to be a goal or purpose for a particular teaching strategy in class. When asked if she would show a video like Madagascar she observed that “it depends on what your
goals would be for watching something like that” (MCI: 58-59) and further posited “depends on the perspective one is looking at this from. What was the assignment?” (MCI: 211-212).

Orientation to Teaching Science

A teacher’s goals about and purposes for teaching science “act as an implicit framework” by which teachers make pedagogical decisions for teaching strategies and influences considerations about learning tasks, student assessment, curricular materials, and instructional strategies (Freidrichsen & Dana, 2005). I believe that Meredith had a combination process/guided inquiry orientation to teaching science (Figure 4-4) that was driven by her goals for her students and how she perceived their abilities, understanding and learning style. Her rationale for teaching, that is, how she planned for lessons and her scheme of assessment, and as well as her teaching style and strategies for teaching demonstrated her OTS.

Goals for teaching

Her process orientation was evidenced by her teaching goals of academic success and excitement for science and guided inquiry by her goals of life skills, concept knowledge, and careers in science for her students. The guided inquiry orientation was proposed by Magnusson and Palincsar (1995) and is an inquiry based approach that “emphasizes the conceptual understandings of science” (p. 44). Meredith had two science goals for her students, namely concept understanding and a career in science. Her science goal for students was that of concept understanding. She spoke of evolution: “quite honestly I do not care what their opinion is … it is kind of like that distinguishing that this is the science part and it is not to be confused with the belief system but it also helps to potentially become more open-minded towards other things and to see that things in science change” (MI1: 272-276). A second science goal for her students was a career in science or as she stated she wanted them to “do something with science.”
Figure 4-4. Meredith’s Orientation to Teaching Science.
She had two general goals for students. A general goal she set for herself was to help her students with life skills. “you know, the how to speak appropriately to one another ‘cause if they were to talk to their boss the way that they talk to each other they would not be employed for very long” (MI1:239-241) Meredith feels that with the more immature students a lot of what she does is “helping them with the functioning in society part.” Meredith’s second general goal of academic success directly correlated to the high-stakes tests her students were required to pass every few years. She spent the first ten minutes of every class period working with her students on test strategies, that is, how to read a table, determine correct answers, etc. She wanted them to question “what do they have in common? What is similar? What is different? So then they can distinguish on things that are the same and different” (MI4: 13-14). She wanted to model for her students how to examine things and start looking at a question scientifically.

An affective goal for Meredith was to generate in her students excitement for science. “I would really love for them to suddenly develop an interest or love for science like I have ‘cause it was definitely my teachers that did that for me” (MI1: 232-233) she commented.

Science curriculum

Meredith believed that curriculum was important to teaching science. She liked to “plan out the entire unit” at a time when looking at her biology curriculum (MI4: 201). “The standards ultimately drive what ends up happening” (MI1: 368) she commented about curriculum. Her county stressed that curriculum should be aligned with standards and Meredith supported that alignment.

She used the textbook as a guide for curriculum but was not happy with it. “The way the book has it set up I do not really care for” (MI4: 207-208) Meredith explains. She chatted about her assignment on the curriculum committee and being given a new copy of the textbook with all
supplements. Meredith added, “the new book comes with a lot of extra resources also” (MI2: 203).

School context

Meredith taught in a rural public school in the south of County One. She instructed students in one period of 8th grade general science, three periods of biology and one period of honors biology. Having three courses to prepare for could cause lesson planning to be a burden but Meredith never mentioned issues with preparation.

Although Meredith had no issues with the facilities in her classroom, she did need technology equipment. When displaying a web site on the LCD projector she needed to be in the front of the room as it had no pointer to move the mouse on her computer. “I would like to move around more but because the computer is upfront and projectors upfront that kind of inhibits my range of motion especially when we are trying to get through a series of things that are moving quickly” (MI4: 24-28). Meredith also suffered from a lack of materials and tends to use different supplies when performing activities utilizing what she has (MI3: 105-107).

Learner characteristics

The students I observed Meredith teaching were in her biology classes. She viewed her students in these classes to have good ability but was disappointed with their motivation. “Individually they’re very sweet. As a group they’re goofy and they wander and they have a hard time staying focused on anything” (MI2: 99-100) she noted. Meredith continued: “they were reluctant to actually do anything. They thought that they could just sit there and not do anything. That THAT would be OK” (MI3: 28-29) she comments. Grouping was a tough problem for her because of her student’ friendliness to each other and she stated, “it is a lot harder on me if I have to pick the groups. . .it is much more time and then they all complain about the groups and
nothing. They do not just comply with anything. So for my sake I just let them pick their groups” (MI3: 67-69).

Student understanding was viewed as varying by Meredith in her classes. Of one student understanding she measured during a recent assessment: “oh, I’m beginning to think very little [retention]. When they took their quiz on mitosis, overall they did not do well.” (MI2: 102-103). She was conflicted about their performance due to the motivation problems “I have different feelings. I think that that’s their responsibility” she stated about student’s paying attention and studying for assessment (MI4: 168) and continued “you just have to use your brain”.

Meredith was aware of student multiple learning styles in her teaching: “they were able to see a visual in addition to them talking about for while” (MI4: 10-11) but struggled with finding the ones that worked with most students. “I’ve tried a lot of different things and so far have not really found something that seems to be a good way or that they’re really perceptive of but I’m still working on it” (MI2: 192-194).

**Rationale for instruction**

Curriculum and assessment play a role in shaping a teacher’s OTS and are seen in their teaching strategies (Lantz & Kass, 1987). Meredith served on the textbook committee and was pleased with her new textbook. They are getting the new version “which comes with a lot of extra resources” which she is using to bring a fresh look to her classroom activities and demonstrations. Looking forward to next year she pondered “possibly next year there’s a chance I could completely and totally rearrange how I do every thing” (MI2: 269-271). This depended on whether she would be the only biology teacher which would give her more flexibility. Lesson planning for Meredith was creative. About one activity doing Venn diagrams to look at similarities and differences in mitosis and meiosis she added “I do not even know where it came from. My brain just decided hmm, let’s do this!” (MI2: 164-165). She searched the World Wide
Web to find sites to use in her class and discovered an awesome one when she “accidentally stumbled on the web site” (MI4: 145-146) which she used in class (MO4).

Standards were a large part of the curriculum where Meredith teaches. “The standards ultimately drive what ends up happening … The standards ultimately drive what ends up happening they’re outlined essentially for what goes on” (MI: 316-317) she commented. Meredith used the biology curriculum outline from another county to help her align her class with the curriculum and standards for her county and state. She was not following the chapters in the book in her unit on cells because the book chopped up the concept with other issues that were not necessary at that time. Another important mediator in curriculum for her was holidays and Meredith did not “want to bore them to death before Christmas” (MI4: 210). She rearranged topics for high interest ones when students were distracted.

Meredith’s assessment of student learning relied greatly on her checking student’s formative understanding of concepts. She observed “I mean technically your assessing when you’re watching them whether they’re doing it correctly or not” (MI2: 254-256). She used quizzes, especially pop quizzes to confirm their participation in group activities as well as to check student’s knowledge prior to more formal assessments. “I wanted to know if they had questions, if they understood what they were doing. Kind of wanted to checkup and see how they were doing” (MI3: 93-94). She assessed with class work, activities, labs, quizzes, projects, and tests making up student’s grades. Testing was for her “the one I just immediately associate with assessment” (MI2: 254) and she continued “it is just ingrained in my head” (MI4: 273).

**Instructional strategies**

Meredith used questioning, hands on activities, web sites, warm-ups at the beginning of class, group work, reading and taking notes, and teaching science skills. Her learning style leaned toward taking notes as she stated: “like I can totally function that way, You know, you
Meredith had activities and projects for her students most days and used the artifacts created in earlier classes to demonstrate to later classes what a product could look like (MI3:61-62). Her hands-on strategy appeared to appeal to most of her students who worked productively on tasks given them. Knowing her students have many different learning styles she stated “it helps to do lots of strategies here to help them with when they’re in their other classes” (MI2: 194-195).

She used proximity for classroom management confiding “if they know I’m walking around it deters them from doing other things they should not be doing” (MI2: 97-98). She employed questioning for testing strategies as well as to check for concept understanding. She utilized the compare and contrast question format working on the process step by step and believed “they had a much higher chance of success because I was helping” (MI4: 247-248). Warm-up activities in her class were applied as “a bit of the metacognition . . . How I was thinking and hopefully how they would see how I was thinking” (MI2: 117-118).

Her teaching style was informal with her encouraging and modeling what she expected of students. “I had to do a lot more provoking and encouraging”, she averred, and expected students to take responsibility with work habits and behavior commenting “I’m not going to walk around and chase them around and say ‘Oh, well you were absent yesterday so you really need to get this done’” (MI4: 170-171). Meredith took prompt action when students misbehaved, sending them to another room to sit with a different science teacher and take notes. All of the science teachers in her wing practiced this form of academic time-out and it worked well as students hated to miss her class.
Alex

Introduction and School Setting

Alex at fifty-three, was an older instructor than his fellow beginning secondary science teachers earning his alternate certification for teaching through the state’s program. He taught ninth grade integrated science, also known as physical science, and tenth grade biology in a small city in the north portion of County Two. He earned a bachelor’s of science degree in biology in the mid 1970s from a Florida university, specializing in cellular and molecular biology. Alex was enrolled in the three-year alternative certification program (ACP) set up by the state of Florida which trained persons with non-teaching degrees to get the pedagogy and training to teach within a structured plan of courses and mentoring. The courses and mentoring were offered during the school year, some as computer classes.

Besides science courses in college he spent six months in laboratory technician training in Mobile Infirmary, in Mobile, Alabama, learning about blood gases and urinalysis. He was among the first group to use a cell microscope in the state of Florida in 1974. Alex worked in hospitals for four or five years as a laboratory technician and held a hospital lab license for many years. He then worked in medical homecare for over twenty years until it changed, “becoming less about healthcare and help than it was about how much money you can make for doing less care” (AI1: 57-58).

As to why he decided to become a science teacher, he stated:

“I always got told by people I worked with that I should be a teacher [because of] the way I taught people at work how to do certain things and how to correct their problems. I have just always wanted to believe I could make a difference in some child. . . You’re not going to make a difference in all of them but if you can make a
difference in some child’s world maybe help a kid that might be thinking of dropping.” (AI1: 60-65)

His desire to help children, to make a difference is what drove him and made him work hard to be a good teacher and role model.

Alex taught at Laurel High School in Rolling Hills, a small city in the north portion of County Two with a population of around 50,000 people. Three-quarters of its residents were white, with one-quarter African-American and other ethnicities. There were 1,790 students at Laurel HS who were white (70%), African-American (20%), Hispanic (5%), Asian (2%) and other ethnicities (3%). Thirty-eight percent of the students were being provided free or reduced lunches. The high school had an experienced teacher population with only 10% in their first year of instruction. Two-thirds of Laurel’s teachers had a bachelor’s degree and one-third attained a master’s degree.

**Classroom Setting**

Alex’s school had a circular structure with classrooms, library and cafeteria placed in a wheel formation around the circle. A secondary building, built in a rectangle held classrooms and restrooms. There were numerous portables, attesting to the reality of more students than the original structure was built for.

The classroom where Alex taught was located in a portable trailer to the east of the main school building by the tennis courts. His was one of a pair of portables to the far eastern side of the school property. The interior of the portable classroom held desks all facing front to the teacher’s desk. Three rows of desks were on the right of the room with an aisle separating the last row of desks placed against the left wall. Behind this row of desks there was an additional desk with eight 2-liter bottles filled with plant matter and soil. Alex explained that this was an experiment being accomplished by his biology class.
Two sets of shelves filled with reference materials were placed at the back of the room. An additional set of shelves was to the right of the entrance door. These shelves contained the classroom set of textbooks for both courses Alex taught. Students did not have a personal set of books but could check them out as needed. A semi-circular table at the back of the room used as overflow seating leaned against the reference shelves with three chairs situated around it and portable cart next to it. The cart held potting soil and a gallon jug half full of water. Alex explained that there was no water source in his classroom so he brought in water for any experiments.

The teacher’s desk was piled high with books and papers. A table situated next to the desk provided additional room for stacking. At the edge of the table, an overhead projector sat perched on seven textbooks to raise it high enough to illuminate a 4’ X 4’ piece of dry erase board being used as a screen. This attached between two chalk boards which stretched the entire front of the room. The right chalk board was filled with names in two columns. Alex explained that it was school policy to announce the high scorers in recent science tests. He had a second column to display the names of students who improved test scores the most in those tests. All students whose names were on the board were awarded a Rice Crispie’s treat.

To the far right, class schedules and other information was posted on the chalk board. The chalk board to the left was employed to illustrate different science concepts and students were allowed at the end of class to draw on the board as they lined up awaiting the bell sounding. Two file cabinets sat on the right side of the room directly in front of the farthest right row of student desks. A TV cart with television and VCR player was next to the file cabinets. Alex’s school computer and printer were jammed into the corner of the room below the far right side of the right chalk board.
Figure 4-5. Alex’s Conception of Teaching Science.
Conception of Teaching Science

Alex had a teacher-centered conception for teaching science (Figure 4-5 above) and held a strong belief that the teacher was needed for any type of teaching and learning to occur. His CTS consisted of the teacher and teaching, teaching strategies, conceptions of science, the learner and learning, and conditions for instruction.

Teachers and teaching

Alex perceived the teacher as the source of knowledge and believed a teacher needed to teach out of a book. He conceived that a teacher could not teach those in grade levels higher or lower than they were trained for. He affirmed this when talking of a particular teaching scenario “a college professor lecturing to first graders. . .I’m not sure that’s the right level either …college professors to me teach on a little higher level than first grade unless they were specialists in elementary teaching” (ACI: 113-115).

His view of teaching was textbook-oriented: “I’d probably rip the college professor out and put a elementary school teacher in there and I, I would have to find a book down to that level, down to first or down to elementary level” (ACI: 126-128). For Alex, teaching was about enthusiasm for his subject and he commented about this throughout his interviews with statements like “I love genetics” and “you start talking genetics, microbiology and statistics, you’re in my class” (ACI: 165-166).

Teaching for Alex consisted of “students telling you what they know and … then you can point out to them what they need to know” (ACI: 46-49). He was unsure whether students can be taught from media and averred “I’m not a big fan of learning a whole lot off of TV” (ACI: 67). He questioned what students would learn and commented “I do not think you get the level of education out of watching TV. . . even if a teacher sent the student home to watch this particular thing” (ACI: 70-71). He saw the possibility of self-teaching but stated “I am kind of borderline
on this. I really do not consider this total teaching” (ACI: 89-90). Alex questioned self-teaching and the motivation students have when he maintained “is it teaching for the ones that do it?” He believed that he could teach students anything with the right materials and student motivation.

**Instructional strategies**

Alex viewed the teacher as the leader in teaching and learning and had several teaching strategies. He discussed the KWL method of teaching where you ask the student what they know, what they want to learn and then after the lesson quiz them on what they have learned. Alex explained about a particular inquiry activity “you’re passing this around and saying ‘what do you already know about these specimens?’ You’re finding out what a student knows in the first place” (ACI: 20-22) and later stated “I would have them show me what they know first and then teach from that point” (ACI: 222-223). Alex saw questioning as teacher-driven and used it to assess what students know or have learned.

He commented about the possibility of students learning from media: I would have the student after they had watched the program tell me exactly what they saw on the TV if I told them to watch this program to see if they could learn … I would quiz the students and find out exactly what they learned when they watched.” (ACI: 60-67)

Alex used the textbook daily and stated he “would teach it out of the book first” (ACI: 156). Alex’s strategies were activity-oriented or “hands-on.” He felt that any activity needed prior teaching first and added “not let them do hands-on the first day. Make them work up to that” (ACI: 158). Alex employed worksheets to focus the student on the learning and envisioned his teaching as very standards-oriented.

**Conceptions of science**

Alex used common terms for science but understood terminology: “I use that [science] terminology quite a bit and with blueberry muffins you have a few chemical reactions there, not
many. You know you got milk and dough and blueberries or whatever” (ACI: 241-243) he commented. He explained the misconception students have between fruits and vegetables: “tomatoes are one of those things that are kind of an oddity in the world that people call a vegetable when they’re a fruit” (ACI: 173-175). Alex believed in the nature of science as fact that can be proved formulaically and stated, “the scientific method is like following a recipe” (ACI: 241).

Learning and learners

Student learning for Alex was visual and kinesthetic with students performing a task in order to learn. He declared that for learning to occur “you have something in front of the students that they can actually look at and put their hands on” (ACI: 33-34). Alex felt that a teacher was needed for learning. He also conceived that media was not a good learning venue for his students: “I think TV, you watch it and at the same time you’re, you’re distracted” (ACI: 68-69). He deemed that in order for learning to occur the teacher needed to question their students specifically about what they learned, to “see well you know what species did you learn about and if they could tell you that then maybe they did gather something from it” (ACI: 73-74) but suspected that “unless [students] wrote it down they probably would not remember” (ACI: 74-75). Alex saw learning as step-wise, stating: “I think the student would actually learn something if they follow a recipe. . .First place, they have to read and second place, they have to follow directions” (ACI:244-245).

He struggled with what teaching and learning was and asserted “is it teaching for the ones that do it? I think they learn how to use something, they learn how to weigh something…the part about it being done at home probably means it would not be, everybody would not get the same teaching level because not everybody is going to do it” (ACI:276-279).
Alex’s view of learners revolved around management issues in his classroom. He viewed learners as untrustworthy: “now frankly if I did this in mine I’d probably by the time I got the box back I’d be missing a few insects” (ACI: 34-35) and “I like a very hands-on thing but in today’s world you have to know what students you’re dealing with for hands-on. I mean there’s classes that I’d give them tomatoes and they’d be splattered up against another child’s head” (ACI: 193-196). He further comprehended them as needing to be motivated to learn especially away from the teacher when he claimed “a student watching a TV program, I’d be surprised if any of my students did that” (ACI: 54-55). Alex perceived students as having prior knowledge and felt he needed to “know what knowledge level the kids already have” (ACI: 24-26). He struggled with what would be age appropriate; “ninth grade I’m not sure is ready for fruit flies” he mused (ACI: 140-141).

**Conditions for instruction**

Alex had few conditions for instruction but his primary one was that a teacher was needed for it to occur. He felt that self-teaching was not real teaching: “is it teaching …? It is kind of self-teaching themselves” (ACI: 88). His major concern was that the standards be taught and had concern about changing standards in his county. “Our school board tells us we have to teach intelligent design along with Darwin’s theory” (ACI: 118-119). Like any first year teacher Alex concerned himself with a lack of materials. He had only two light microscopes for his biology class of twelve students and his concern for enough materials for his students was evidenced by his statement: “in the regular classes we do not have enough to go around” (ACI: 141-143).

**Orientation to Teaching Science**

Alex’s orientation to teaching science was activity-driven (Figure 4-6) based on his goals for instruction, science curriculum, school context, learner characteristics, rationale for
Figure 4-6. Alex’s Orientation to Teaching Science.
instruction and instructional strategies. His orientation was evidenced by his science teaching goals of science skills and content knowledge, and general goal of life skills. This activity-driven approach was proposed by Anderson and Smith (1987, cited in Magnusson, Krajcik & Borko, 1999) and had as its goal to “have students be active with materials; ‘hands-on’ experiences” (p. 16). This epitomized Alex’s oft-stated practices of having students “do the hands-on” activities and his lesson planning focus of building models and demonstrations that allowed students to verify or discover science concepts kinesthetically.

Goals for teaching

Alex had several science goals and one of his most important was to give student’s concept understanding or as he stated a science base that they can build upon in future classes. “Newton’s laws, Aristotle’s laws, you know, momentum, gravity, because they and I tell them they use these in other facets of life for instance, in momentum in stopping distances” (AI1:224-226) he explained about his view of concept understanding in his integrated science class. About another class he spoke: “the goal again is to get them to learn what a projectile is, what a satellite is, what the curvature is called” (AI1:176-277).

A second important science goal for Alex was science skills. In talking of a class on microscopes and looking at cells he stated “the basic goal was for them to at least use a microscope . . . at least get them some hands-on with a microscope and with slides, with cover slips, things of that sort” (II3:111-113). He discussed science skills on several occasions in interviews.

Alex’s third science goal was to guide students in a choice of science careers: “what I want them to get out of it is to decide if they really think science is something they want to pursue” (AI1:195-196). Alex counseled students and stated “I try to figure out which students are better
adapted for like maybe taking biology next year or which students may be better on the chemistry side or even get to a physics side” (AI1:197-199).

Alex cherished two general goals as well. He spent time working to motivate his students to do well in school as his academic success goal. “You’re not going to always achieve it but always shoot for an A in class and if you do your work and a C’s the best you can do then that’s fine but if you sit there and shoot for a C you’re probably going to get a D or an F.” (AI1:442-445) he commented. A part of this goal was to help them pass the state high-stakes test necessary for their graduation from high school. When speaking of his goals for his students he exclaimed “well to pass the test would be nice” but became serious in talking of the high-stakes test “I would like to see students leave here and be able to do as well as possible when it comes time to take that FCAT” (AI2:124-125).

A second general goal was to help students develop life skills. This was part of his strong desire to work with children. “If I can I can help them through not only the science part but also any problems they have in the 9th grade” and expressed what brought him into teaching was to “make a difference in a kid’s life” (AI: 71-73).

Alex’s affective goal was to motivate students and stimulate their interest in science. When he spoke of his demonstrations, Alex explained “I try to give them those kinds of things for science to relate gravity as something in modern-day that they may find the gravity to relate momentum.” (AI2:233-235). Getting students to relate science to the real world is the route by which he motivated students to learn science.

**Science curriculum**

Alex believed that curriculum was important and ensured that it was taught in a progression of concepts (AI3: 222-223). Curriculum must “fit into the standard” (AI3: 224) he stated, adding “the school curriculum just makes us follow the state’s curriculum” (AI2: 483).
Alex was very dependant on the textbook and commented “you can only teach what the book says to teach” (AI1: 185-187). Although very dependent on the textbook he also jumped around in text when teaching (AI1: 221-223) to tie like concepts together in a progression that his students would understand.

**School context**

Alex taught at an urban public school in a small city in the northern part of County Two. He instructed students in four classes of integrated science and one class of biology on the block schedule. This participant was the only one who taught science on a block schedule.

There were numerous teacher issues Alex faced. His most critical one was a lack of proper equipment and facilities. “Our only handicap is that we have only two microscopes. I’d like to have a microscope for every student” (AI3: 160-161). His classroom being portable there were no facilities for experiments including a lack of plumbing for water and sinks, lab stations or cabinets. Alex also had only a classroom set of books so his students could only do seatwork and no homework (AI1: 308-309).

Other issues for Alex were no budget for materials, lack of time to lesson plan, and high-stakes testing. “Mainly I end up getting my own materials. There’s not a lot of materials (AI1: 154-155) Alex stated. A lack of time to lesson plan was an issue he shared with other participants spending up to “six to seven hours” planning and constructing demo materials (AI2: 389-391). High-stakes testing was accomplished in his school and he worried about student preparedness for the tests.

Alex had other factors which were part of his school context. He was required to submit lesson plans to the administration. “Our [administrator] just requires us to have copies or have them on the computer” (AI2: 534) he added. In public schools the principal or vice principal
observes teaching several times a year. Observations are more frequent during a teacher’s first year instructing.

**Learner characteristics**

Alex taught an integrated science course, considered in his school the lower track in science for freshman high school students. Many of his students had special needs. Alex saw student ability in these classes as going “from the lower standard to the higher standard education-wise” (AI2: 88) and expressed concern about the difficulty of teaching such a wide range of students for a first-year teacher. “It is tough, it really is and especially being a first-year teacher the way I’m teaching it is tough teaching that whole gamut of students” (AI2: 122-124).

Discipline was a difficult issue in these classes and Alex expressed concern about a particular student: “this child has a hearing, hearing problem. He has eye problems and he has a learning disability but he sits up front right in front of me and sometimes he’s so far off the subject on questions and I just let him talk” (AI2: 841-843). Talking in his classes was a difficult management problem for him. When sharing issues about his biology class he remarked: “you still have the problems. You still have the talkative ones. You still have the ones a couple of them do not pay attention. But I don’t think it is as noticeable at the tenth grade level or the eleventh grade level” (AI2: 169-172)

Student motivation was another issue that Alex worked on in all his classes. He was happy when students showed interest by asking questions and noted “even though sometimes the questions are far off the track at least they’re asking questions” (II4: 171-172). When speaking of his biology class, Alex had a differing opinion “most are there because they are interested in biology. There’s a few that are there just because it is a core, it is a second science for them” (AI3: 35-36) but felt that most are there because they “chose to be in biology.”
Student understanding was positively viewed by Alex in his biology class. “the biology students seem to, from the testing, have a good grasp on the subject and seem to have a good interest in the subject on the whole” (AI2: 151-152). He shared a different view of his integrated science student’s understanding of topics when he stated, “the ones I can get through to I think are grasping some of the major facets of the science” (AI2: 111-112). Alex continued “I think this particular type of student thinks ‘once I’m finished with chapter one I’m finished with everything.’ And they do not realize it goes from one chapter to another” (AI2: 181-183).

Alex distinguished his student’s main learning styles as group work and asking questions. In talking about one of his biology students, he explained, “this child’s trying to learn something and the questions this particular student asks are very good questions about the world and about biology” (AI2: 324-325). One problem he found is that when he assigned groups students did not stay where they were assigned. “You know, I do not think it is just me. I think that is probably a commonplace event”, he mused (AI: 288-289).

**Rationale for instruction**

Alex’s OTS was shaped by curriculum choices as seen in lesson planning and assessment. His main curriculum source remained the textbook and he spent hours planning lessons using the text and supplemental materials his school provided him. “Just to do the first three sections of chapter eight probably took me six to seven hours to get everything prepared by the time I went and got the stuff I needed” (AI2: 389-391). Having learned this text, Alex shared his views about the new text they were acquiring, “the sad part is that this book is going away after this year so next year we will, we will be changing totally to a different book which can be good and bad” (AI2: 490-492). He used state standards to ensure that all topics of the required curriculum were covered and commented “it is a case of having to pick out what is important and you know I
have to look at the state standards and see what the state says has to be accentuated out of that particular chapter” (AI3: 202-204).

Alex carefully crafted his lessons, explaining: “I read the entire unit through and it tells me where to go to the other resource books and any other type of exercises or handouts we can find for them. I read exactly what the kids will be reading, highlight or find the words that need to be expounded on and then use the other resources to accentuate them to add to it” (AI4: 112-118). He preferred to summarize the chapters and units providing “a decent summary before a test” and accomplished this using “all the preparation materials I can find” and many times borrowed ideas, activities, and worksheets from other teachers (AI3: 182-186).

Alex assessed student learning by testing. He, like other teachers in his school was tasked with raising student’s reading scores on the high-stakes tests. He observed “it has been identified as one of the big weaknesses of students is reading” (II2: 44-45). To improve scores students were required to read at least 10 minutes in each class. Since his school day was set on the block schedule, Alex used this time to have students read sections in their science textbook.

In addition he used other assessment tools “things like homework or lab or sometimes you know just how well they participate in class to arrive at the grade” (AI3: 310-312). Class participation was an important alternate assessment tool for Alex. “[O]f my total assessment of the course, testing is one way but I also look at them and see how interested they actually are and some of that is from their feedback as far as acting, asking questions” (AI4: 177-180) he stated.

**Instructional strategies**

Alex employed various strategies for teaching science. He drew on written questions, definitions on the transparencies, questioning, demos, activities, labs, lecture, and discussion to keep his classes interested. Of one of the demos he had done he stated, “of course the purpose is to try to get it across to the students effectively. What does that best is really just like the little
demonstrations model I’ve done” (AI2:15-17). Alex spent long hours making models for his integrated science classes to illustrate and demonstrate concepts. Labs were especially important for him in his biology classes. “Anytime I do a lesson that goes well I try to have some sort of experiment that the kids like to do” (AI1:115-116). Alex preferred his biology students experience individual labs to develop their skills with science equipment and to get experience doing experiments.

Alex’s teaching style was informal and kinesthetic, with him rolling balls down the aisles to students to illustrate physical science concepts or having students swing a pail of water over their heads to demonstrate centrifugal force. “Anything they can see even dropping a ball rather than simply walking about or pointing to it in the book” (AI2:17-18) was the teaching style he most espoused. His style for concept understanding was to “break it down into sections and try to get a further understanding” (AI1:180-181). Although very activity-driven, Alex felt “hands-on sometimes takes a back seat to what you have to learn to build up to the hands-on” (AI1:122-123).

**Cristina**

**Introduction and School Setting**

Cristina, in her early twenties, was in her first year teaching high school biology and marine science at a private Catholic school in Rolling Hills, in County Two. She was working towards alternative certification in teaching and required by her school to attend teacher education classes and pass her certification exams within two years as well as some catechism courses through the Catholic dioceses.

Cristina earned her degree in biology with a specialization in marine science in 2004 from a university in the northeast United States. She focused her course work on zoology, animal behavior, evolutionary biology, marine science, and marine mammalogy at the organismal level.
As part of a course, she took a field trip for two weeks to study sperm whales aboard a boat off the coast of Dominica in the West Indies.

When I asked Cristina how she decided on teaching as a career she stated:

“I was planning on going to graduate school . . . and then at the last minute the professor lost funding so I was not able to [go to] the grad school and my sister suggested that I teach at a Catholic school for two years and that’s kind of how I became a teacher. And through all of this I'm beginning to think that my role maybe, this is where I'm supposed to be because I’m, I cannot believe how happy I am here, what I’m doing. So I think that God kind of gave me a kick in the right direction here” (CI1: 53-59).

Cristina taught at Sacred Heart High School in Rolling Hills, in the same city as Alex. The private Catholic school was built in 2002 and there were 454 students, including white (79%), African-American (6%), Hispanic (12%) and Asian or other ethnicities (3%). The science department consisted of five teachers and had two teachers in their first year of instruction. Fifty-nine percent of Sacred Heart’s teachers had a bachelor’s degree, thirty-eight percent attained a master’s degree and one had a doctorate.

Classroom Setting

Because her school was built in 2002, Cristina’s classroom was new and well-equipped. The left side of the room featured three windows that looked out on a lawn dotted with trees and picnic tables. Between each window pictures and posters depicting different concepts of science were hung. The television was mounted in the left front corner of the room directly above a bookcase holding books of various types. Atop the bookcase sat a terrarium. As she lectured to her classes Christina advanced PowerPoint slides on the TV assuming a hookup from the computer to television.
The front of the room displayed a Whiteboard in the center and a bulletin board between Whiteboard and door. The bulletin board showcased posters of estuaries and other habitats and a poster with a religious figure affixed to it. On the right side of the room were two doors, one at the front of the room and the other at the back of the room. Between the two doors sat a terrarium, a two-door cabinet in a large alcove and another two-door cabinet in a second roomy alcove.

To the back of room were mounted two bulletin boards, one with biome posters on it and one with a world map. Below the bulletin boards two tables were placed with four plastic rectangular trays on each. The trays each held four six-inch flower pots with grasses planted in them. Two trays on the first table were labeled ‘10% organic amendment’ and the other two labeled ‘5% organic amendment’. On the second table two trays were labeled ‘Miracle Gro’ and ‘H₂O’. They were the implements of one of the actual studies that Cristina explained were in progress.

Against the back wall stood a large blue plastic trash can, two student desks and a long table with three student chairs pulled up underneath. The long table had four aquariums each labeled ‘H₂O’, Miracle Gro’, ‘5% organic amendment’ and ‘10% organic amendment’ on their sides. I assumed these were for the second grant that Cristina is accomplishing during her school year. On the left rear of the room (before the first window) lies a long low bookcase with three shelves. On each of the shelves shells and marine specimens were located.

To the right of the TV were about five or six different posters on science tacked to the wall. In front of them was placed a computer with monitor, keyboard, and mouse attached to it. The teacher's desk faced the room at an angle. A small aquarium lay to the left of the teacher's
desk on a small end table. Desks were aligned in rows facing the front of the classroom, each with a chair and four or five chairs per vertical row.

**Conception of Teaching Science**

Cristina had a teacher-centered conception for teaching science (Figure 4-7) consisting of teachers and teaching, instructional strategies, conceptions of science, learners and learning, and conditions for instruction.

**Teachers and teaching**

She perceived the teacher as the source of knowledge and believed a good teacher could “take any subject and teach it in a way that [students] can understand” (CCI: 118-120). Cristina further felt a teacher’s attitude determined whether they “could teach the kid you know why and how [something occurs]” (CCI: 213). Her college professor advisor was a strong mentor and she had a belief he could teach anyone at their level: “I have a picture in my head of my college professor lecturing to first graders” (CCI: 124-125).

“Kind of for me teaching is active teaching” (CCI: 191) was how Cristina described her conception of teaching. She categorized the ways a teacher instructed into what was or was not “active teaching.” Cristina envisioned inquiry as in her words, “a general open-ended question . . . it is more of an inquiry process . . . it is not active teaching” (CCI: 45-46). She further explained, “I use inquiry kind of like open-ended inquiry like that at the start and then I begin my teaching” (CCI: 47-48).

Cristina separated her teaching into parts, seeing questioning as “the beginning part of teaching.” Inquiry for her was not teaching but only the start. She felt strongly that students should learn in conjunction with a teacher and questioned if self-teaching were possible. Cristina averred “I do not think that just reading a guide is, is again it is not active teaching. . .I think that’s more of research and gathering information” (CCI: 262-265).
Figure 4-7. Cristina’s Conception of Teaching Science.
Instructional Strategies

Cristina used questioning as an important strategy and stated “I always try to use scientific terms” when questioning students (CCI: 27-28). She employed probing questions to find out student prior knowledge and to keep them “on task” (CCI: 48-50). If Cristina used inquiry she would use only elements of it as a precursor to teaching (CCI: 46-47). She utilized media to illustrate or introduce topics stating, “I feel that that is an excellent way for the kids to see the organisms and they are actively participating most of them,” (CCI: 74-75).

Cristina used labs but was still building her library of appropriate lab activities. She purchased a teaching aid having activities she drew on in her instruction. She also had students accomplish seatwork. As Cristina explained, “I do assignments with the kids in which I’m not actively teaching” (CCI: 191-192).

Conceptions of science

Cristina viewed science as a body of knowledge driven by a questions and she saw the learning of science as a progression of the content. She felt learning was built upon prior knowledge given by the teacher. When looking at a question of particular knowledge a student had on bones she visualized student background knowledge in terms of what had been already covered. “So they have to have learned it at some point so how did they learn the bones to begin with? If they had had a big unit where they did an activity to learn the bones together then this would be part of that lesson” (CCI: 184-187) she muses.

Cristina believed the nature of science was human-conceived when she claimed that the student needed to “start to think about the difference between what we perceive and like [what is] common in society and science” (CCI: 171-172). She perceived that students had misconceptions and tried to inform her students that “there [are] misconceptions in the world and
Learning and learners

Learning for Cristina was active with students performing a task or actively paying attention in order to learn. “If the student is sitting there and actually responding to what’s going on … I would know that there is teaching and learning going on” (CCI: 81-84) she commented about using media for learning. In a particular scenario she saw learning happening between students “if one of them did not understand . . . what a calorie is or … to figure out the caloric value for different foods and the other person was explaining somehow then that would be science teaching” (CCI: 101-104) but was hesitant about a student learning alone when cooking commenting “there’d probably be someone to help them follow that recipe” (CCI: 229-230).

She understood her students had misconceptions and would inform them “there [are] misconceptions in the world and what science really teaches us” (CCI: 173-174). Cristina realizes that her students had some prior knowledge about science topics. “Once I started talking about the material they will say ‘Oh I remember that from last year’ and I knew that they knew what it was” (CI2: 229-230).

Cristina viewed learners as needing to be guided to learn and refocused onto the learning task. In class she would scan the room and challenge students to focus and pay attention. She also felt the need for students to have specific questions asked of them in order to promote the right conditions for learning. “When I’m teaching and I ask questions they’re more specific questions to help keep the kids on task. . . If they do not have a specific question they just kind of turn it into a joke” (CCI: 49-50, 53). Finally she believed a student’s age and cognitive level determined whether learning were accomplished. When talking of inquiry she felt “for my students anyways it is just something that they could not handle” (CCI: 61-62).
Conditions for instruction

Cristina had many conditions for teaching. She believed teaching was accomplished when “you’re describing the steps … and not just listing them” (CCI: 148-149). Cristina stated for a teacher to simply give students a worksheet was wrong. “If the teacher simply stood in front of the class and passed out this is and said ‘label this’, that’s not really teaching. . .that’s more like note taking before the teaching” (CCI:188-189) she averred. Cristina believed that student participation determined the quality of teaching. She commented about students watching a video “if they’re just sitting there with their hand on their cheek spacing out you know I do not think that is teaching happening” (CCI: 75-76).

Cristina deemed questioning as a strong condition for teaching and demanded the questions be specific: “[if] it is a specific question then … it is going to make them start to think about the difference between what we perceive and like [what is] common in society and science” (CCI: 169-172). How the teacher responded to a question was also important, she declared. “I always try to ask, ‘what can we hypothesize about this?’” (CCI: 40) A student working alone and doing calculations was not a good condition of teaching to her. “You know they are probably just following standard procedure that they have to do . . . following a formula, plugging it in” (CCI: 97-98) and further posited “I do not think that’s science teaching.”

Cristina also had conditions for learning. It was important to her that the knowledge learned be first-time knowledge. She talked about cooking and questioned “is this the first time that they’re making muffins? If it is the first time they’ve made anything in baking they’re going to be learning” (CCI: 226-227). In discussing a scenario of a teacher writing a self-study guide she commented “I do not think the teacher would be learning and I do not necessarily agree that like a self-study course is real learning” (CCI: 254-256). A final condition for learning she felt
was student interest and Cristina felt students were actively learning if they commented about it (CCI: 85-89).

**Orientation to Teaching Science**

Cristina had a combination academic rigor/didactic orientation to teaching science (Figure 4-8) powered by her teaching goals for her students and learner characteristics, science curriculum, school context, rationale for teaching and instructional strategies. “An orientation represents a general way of viewing or conceptualizing science teaching” (Magnusson, Krajcik & Borko, 1999, p. 97) and helps guide decisions of teaching strategies and curriculum.

**Goals for teaching**

The goal of teachers with an academic rigor orientation is to represent a particular body of knowledge and this was the primary science goal Cristina held. She wanted her students to get concept knowledge “outside of what we were talking about and to you know I like them to visualize what’s going on” (CI: 87-88) and “get them comfortable using science terms” A secondary science goal for students was for them to view science as real-world. Cristina related a science connection she had taught recently: “I remember spending five solid minutes in class talking about weightlifting and lactic acid and all those guys, their eyes were right on me” (CI1: 361-364). She tried to tie her lessons to what interested students and helped them to retain information.

She had a general goal for her students of academic preparation. This Cristina felt could be achieved partly by learning how to research and write about it. She stated, “I want them at the end of the year to write a research paper in which they found all their resources by using a database like you do in college” (PI: 266-268).
Figure 4-8. Cristina’s Orientation to Teaching Science.
Christina had an affective goal of excitement for science. First, she wanted her students “engaged in the lesson” and tried to encourage them daily to keep involved. If she saw students going off task she would have them stand and refocus them with several statements that they had to repeat. Cristina believed that the teacher needed to move quickly through the topics and have “like a crash course of everything at the beginning or something like that just so the kids can see that there’s really exciting stuff that can be had” (CI1:389-391) and repeats “I just want them excited about the material.” She called this her ultimate goal.

Science curriculum

Curriculum was important to Cristina: “this is just the beginning of the stuff that I want them to learn this semester. We want to talk about genetics and DNA and move as quickly as we can into the organismal levels” (CI2: 257-259). She viewed curriculum as the textbook and discussed sections she wants to cover. “I want to cover all of the areas in the book” (CI1: 284) she commented. Cristina feels she cannot teach without the textbook (CI1: 384).

Even though she used the textbook as course curriculum there were problems with it to her. “There’s too much detail in these books for kids and I wish that they had more ideas for hands-on activities” (CI1: 387-388) Cristina bemoaned. An ideal textbook would have the topics broken into small sections to teach. As she worked through the text Cristina simplified concepts she felt would not be understood (CI1: 351-354).

School context

Cristina taught at an urban private school in County Two. Her school was a parochial high school which was two years old. She instructed her students in three classes of biology and two classes of marine science daily.

There were many teacher issues Cristina dealt with. She had a lack of proper teaching aids and purchased her own (CI3: 157-158). Her classroom was fitted with a television, computer,
and video equipment to enable her to present her lessons using PowerPoint slides. Unfortunately she had no pointing device needed to hover close to her computer to change slides. Cristina did not have a budget for materials and had to use what she had on hand (CI1: 172-174). Finally, there was little time for her to lesson plan as she worked as a tutor after school (CI1: 121-122).

Learner characteristics

I observed Cristina teaching two different biology classes. She viewed her students’ abilities as varying, stating “well it is kind of a mixed class. There are some of them that just do not get it and you have to really, really work with them and there’s some that are, they think higher but not to the extent that my third period class does” (CI2:103-105).

Cristina found she had to motivate students as they got bored with the amount of note-taking done in her classes. She got excited with her student’s excitement, “you know kids they get excited when they can figure something out for themselves” (CI2:84-85). To stimulate motivation she used questioning stating “I am sure you could tell who I kept calling on, the people who are not actively participating” (CI2:174-175).

Student understanding was viewed positively by Cristina in her classes. “I think overall they do understand it and they’re really excited about this stuff that I teach” (CI2:122-123). She worked to improve student performance due to the motivation problems. “A lot of them will think that they know the material so that they can just sit back and you know say ‘Well I already know Punnett squares so I’m not going to pay attention’” (CI4:57-60) so she called on them to answer questions.

Cristina was attempting to understand student learning styles and wondered “they’re just blindly like writing down whatever we throw on the overhead or you know if it is fill-in-the-blank notes they will fill the blank or whatever so you can feel that the kids, they just shut down” (CI1:259-261) but struggled with finding a strategy that worked with most students “I’m always
trying to get kids to do problems in their head ‘cause I'm a visual person so I can always visualize stuff like that in my head.” (CI4:89-91).

Rationale for instruction

Curriculum and assessment affect and are affected by a teacher’s OTS (Magnusson, Krajcik & Borko, 1999). Cristina was dependent on her text and believed she “could not teach without a textbook obviously.” She tried to cover all of the chapters of the book but felt rushed as the “fun stuff” on animals was in the back. Cristina was unhappy with her text stating that “there is too much detail in these books for kids and I wish that they had more ideas for hands-on activities” (CI: 387-388) and wanted to reorder sections of the book to be able to spend more time on organisms. Her school, being private had no high-stakes testing or standards for her to follow so she had to teach within the construct of what the textbook presented.

Lesson planning for Cristina was difficult due to lack of preparation time (she tutored afternoons and evenings) and her limited knowledge of appropriate activities and labs. During her lesson planning sessions she “might use the internet, college textbooks, online lesson plans” (CI2:246) and was always trying to add extra material. Her school did not give her a budget for materials so she purchased a packet of activities to use in biology instruction.

Assessment of student learning was very traditional for Cristina both through personal preference “I do not really do alternative assessment” and because the school only allowed traditional methods. Her student’s grades were based on homework, labs, quizzes and tests with an occasional project thrown in. When I mentioned assessment she talked to me of the types of questions she would have on the test. She commented that assessments were “helping me with knowing if they understand the chapter, were paying attention and were taking notes” (CI4:141-142).
**Instructional strategies**

The teaching strategies used by Cristina were focused around her didactic orientation and relied heavily on lecture, note taking, and technology. She attempted to “rush through” parts of the book she felt were difficult or boring. She used many pen and paper in-class assignments which could be taken home to complete stating “that’s like a teacher’s saving grace when you’re just so overwhelmed by things and you just say ‘okay, read these pages, answer these questions’ and then you can spend that hour catching up on whatever you have to do” (CI1:230-233).

Cristina relied on questioning to review concepts and keep students focused. Her teaching strategy was to just “keep on asking them questions instead of just sitting there and giving them notes” (CI4:17-18) She employed questions to keep students on task feeling “if they know that I’m going to randomly call on them” her students would remain focused throughout the period. Worksheets were used as a review of the material and done several times a week. Cristina had one project during the fall where her students constructed a cell. Daily at the beginning of class students were questioned about terms and content covered the day before.

Cristina’s teaching style was formal with her as the authority figure in the classroom. She required her students to focus on her and respond to her. Her classes were strongly lecture driven and her students took numerous notes. Cristina believed, “you have to take notes; it is almost impossible not to take any notes” (CI1:257-258). The core of her teaching style was to make connections averring, “I tried not to just jump right in to a new topic. I think it is important that we tried to link what they already know about it with what we talked about before” (CI2:33-34).

**Isobel**

**Introduction and School Setting**

Isobel, in her early thirties, taught at a high school in a small town in County Three and was becoming alternatively certified. This required her to take education courses and to pass the
general knowledge, subject area, and professional educator’s exams. She earned two bachelor’s degrees, one in marine biology and one in ecology as well as a master’s in science.

Coursework for her undergraduate science degrees consisted of various courses on fish structure and behavior, fish biology, coral reef fish ecology, plant classes, developmental biology, evolution, and many ecology courses. For her master’s she completed aquatic and environmental chemistry, engineering, hydro-geology, groundwater flow modeling, and biome restoration coursework.

She completed a work study with a plasmobiologist studying sharks and stingrays. During her master’s degree she had an internship with a local water management district and designed a project to measure whether phosphorus could be naturally removed using wetlands, collected the data and made feasibility calculations.

When I asked why she became a science teacher, Isobel responded with:

“I was going to be a marine biologist. . . decided I can not live on eight dollars an hour so I got into business and I found skills that I did not know I had. . .I went back to school and I really got into it. I found I was really good at presentations and I liked public speaking. . . [after college in a job] I got tired of computers and I thought you know I’m going to try this and I have been pleasantly surprised.”

Isobel taught environmental science, honors chemistry, and anatomy and physiology at Forest High School in Forest, a small city of about 4,000 in County Three. The 477 students at Forest HS were white (56%), African-American (40%), Hispanic (3%) and other ethnicities (1%). Fifty-eight percent of the students were being provided free or reduced lunches. The high school had an experienced teacher population with only 16% in their first year of instruction.
Three-quarters of Forest’s teachers had a bachelor’s degree and one-quarter attained a master’s degree.

**Classroom Setting**

Isobel’s classroom was a cinderblock structure with two doors, one opening to the outside and another that opens into a science preparation area. Doors were positioned at the front and rear of the room on the left side. Most of the left wall was taken up by cabinets. Sixteen narrow cabinets with doors on the bottom and middle portions were attached to the wall with two square shelves above them. These bookcases had their shelves filled with books, workbooks and science materials.

A three-door cabinet wash placed on the left side of the room near the rear door. At the rear door of her classroom on the left were mounted a fire blanket and fire alarm. The rear of the room to the right of the door displayed mounted posters and a skeleton hung next to the rear wall in the right rear corner of the room. On the left rear corner of the room the fume hood with a light was installed. It contained gas and water jets and experiments could be performed inside it. Forward of the fume hood on a simulated wood counter stood a blue metal cabinet marked “Corrosive”. Forward of this cabinet stood a yellow metal cabinet labeled “Flammable” also atop a simulated wood counter. Both cabinets held chemicals used in her classes.

Forward of the cabinets a long computer carrel was setup for three computers. The counter top appeared to be a blue laminate material with the legs of the structure painted blue. Three monitors with keyboards and mice sit atop the counter and three computer towers are placed directly below each set of equipment. Under each of the three sections of counter is shoved a formed plastic chair. At the front of the room stand a tan four-drawer metal file cabinet and two brown metal four-drawer cabinets.

A rolling one-drawer black metal cabinet sat forward of other file cabinets. A square
table was arranged in the front corner and atop it a large stack of papers was placed on left side and a small stack of papers on the right. Directly above a wooden platform was attached to the wall with a VHS player, DVD player and switcher resting atop it. A black twenty-inch color television was mounted to left wall near front of room.

Bulletin boards were hung to the left and right of two seven foot wide dry erase boards attached to the center and a projector screen mounted above them. A retractable map was located to left of the screen. The right-hand bulletin board was decorated with vocabulary words and the right with sports memorabilia.

**Conception of Teaching Science**

Isobel had a developing student-centered conception of teaching science that was teacher-centered (Figure 4-9) consisting her conceptions of teachers and teaching, instructional strategies, conceptions of science, conceptions of learners and learning, and conditions for instruction.

**Teachers and teaching**

She viewed the teacher as the source of knowledge who can teach only to a specific age group unless specially trained. When speaking of a professor teaching first graders she stated “if he can break it down to where six-year olds can understand that, the man’s a genius” (ICI:78-79). She believed that activities should be tailored to fit the age or cognitive level of the learner and was developing an understanding of how to modify content. Isobel felt a teacher have the ability to demonstrate a topic in order for teaching to be happening. She averred “that’s probably the biggest key for me. You can describe it but can you demonstrate it? Can you show?” (ICI: 101-102). Isobel was knowledgeable in science, and content knowledge was important to her. She believed that teachers “have to be knowledgeable. . .they have to know what’s going on. If they do not, they better find out” (ICI: 215-216).
Figure 4-9. Isobel’s Conception of Teaching Science.
Teaching came in various forms for Isobel. She viewed teaching as interactive and hands-on: “so you are saying it and then showing them and having them do it with you so not only do they hear it, they see it but then they do it then you’ve probably got teaching” (ICI:90-92).

Isobel’s say it, show it, have them do it form of teaching permeated her classroom instruction and led her to use demonstration and experimentation as a part of her daily teaching strategies. In each class I observed she used this format to present new material to students.

Isobel believed students could teach themselves through activities like cooking. When talking of teaching stoichiometry to her students she stated “we kept going through it. I finally got them to understand with cooking and cookies [as] limiting reagents. You do not have enough chocolate chips you’re going to make less chocolate chip cookies” (II2:72-75). She perceived students need to “grasp following methodology to a T and if you do not, what the repercussions are going to be so even though it is real simple” (ICI: 182-184).

Student’s teaching each other was also possible to Isobel but she had trouble visualizing what it looked like as she posed to herself “are they asking each other questions and kind of teaching each other?” (ICI: 61-62) and later explained what kinds of student interactions would be teaching to her “like one knows one part, one knows another and they’re saying ‘Well I do not understand this. Can you explain this to me?’ that would definitely be more teaching” (ICI: 62-64).

Isobel perceived teaching could be accomplished using media both through video and the written word. Of video she felt it could teach if students make a conscious decision to watch something educational and stated “they are not flipping it around to MTV. They are not flipping it around to The Simpson’s. They are actually watching something that they could get something from and ask questions about later” (ICI: 41-44). Self-study guides could be teaching tools but
Isobel averred “you are going to have to be able to read it and understand it.” She grasped the importance of teaching to a student’s learning style but felt that a teacher should explain things first. Isobel asked “did you give them any background?” when questioned about whether teaching was going on in a particular instance.

**Instructional strategies**

Isobel recognized that questioning was important as a strategy and required her questioning be focused. When asked about an assignment for students to draw apparatus and label something they have observed she questioned:

“Then in addition to label it, what is its function? What does it do? Otherwise I would ask more of ‘well what really happened? Can you explain it using as much science as possible? You may use apparatus. You may use theory, whenever you need to do. Can you explain what you saw?’” (ICI: 136-139).

Demonstrating was very important to her. In her class to illustrate gas laws, Isobel used a balloon, diagrams, dry ice, aluminum cans, and other items to show her students how gases acted in a closed system. She wanted to have students perform experiments in her class but worried about lack of equipment or supplies for many labs. Looking for labs that could be done with household materials and simple equipment was something she most wished she had more time for.

**Conceptions of science**

Science content was important to Isobel hence her two bachelors and one master’s degree in science. She conceived science as a body of knowledge whose outcomes impact society. A project she designed for her students examined medicine’s impact: “I wanted some different sources. I wanted one ‘Oh, medicine is great’ because that’s what we think [when] we really
need to rethink about these medical advances. How maybe they're not being handled right, a kind of a more of a negative spin or a different look at it” (II3:211-215).

Isobel used the book as a resource for her students and had them work through problems in it to demonstrate the process in problem-solving. She was in the process of choosing texts for next year and very carefully assessed which text would teach the concepts her students required at the level they read and understood. In her chemistry class she was “jumping around” the book progressing from concept to concept as she viewed them tied together as curriculum.

Isobel never spoke directly of the nature of science but saw science as empirical and flexible utilizing problem-solving, observation and inference with her students to teach concepts. She understood the scientific process and saw her students as scientists when they would bake at home stating: “Well first of all can he follow directions, methodology? If the student did not and it was incorrect what was his reaction and how would he deal with it? …So it is kind of like ‘well my hypothesis failed. Did not come out so what are my errors in can I go back and replicate it’ which is what you do and try to get the correct outcome” (ICI: 190-191, 193-194).

**Learning and learners**

Learning for Isobel was visual and kinesthetic with students performing a task in order to learn (ICI: 133-136). Learning from doing was important for her. She stated “anytime you write on how to do something you’re learning” and further commented “a lot of times when you write and when you explain things you find out that you have to know it a lot better than just knowing it” (ICI: 204-205).

She saw students also making a conscious decision to learn. “First of all you’ve got a student at home whose watching a TV program on chemical plants. That's not something that [they’re forced to do], that’s a conscious decision (ICI: 40-41).
Isobel felt that students could learn on their own without a teacher present. On self-learning she saw it as practicing and observing: “it is more of learning on your own thing. Yes you’ve been taught. Now can you do it? Can you replicate?” (ICI: 65-66) She saw clearly that peer learning was social and stated “if they’re working together and talking to one then yeah they are teaching one another” (ICI: 66-67).

Isobel saw learners as needing motivation in order to learn away from the teacher and mentioned of her students “the fact that they’re watching chemical plants and plastics from coal I, my students would not watch this. Not at home” (ICI: 51-53). Age and cognitive level were also characteristics she recognized in learners when she acknowledged “It may be you have to start at that level for those students ‘cause I’ve got a class I’d have to start at that level” (ICI: 7-8) but was unsure of exactly what grade level this should be stating “middle schools kind of” when searching for the age or cognitive level to present an inquiry lesson on crystals.

Isobel, when presented with a scenario where a student stated a misconception, felt that “maybe they do not know when those things happen” and declared “it is a prime opportunity [to] go ‘Well those are good questions this is how you would figure it out. Why do not you come on up and check and then you can do. . .’” (ICI: 164-167). Isobel felt she could explain concepts and have students accept her explanation but was developing an understanding of student conceptions and how to teach for conceptual change.

**Conditions for instruction**

Isobel had specific conditions for teaching. She did not perceive inquiry as teaching but rather viewed open-ended questions as a “kind of an opening icebreaker to get you to start talking about it [science topic]” (ICI: 19) and stated “that's fine because then they will go ‘Well I use crystals in this’ and ‘we do this and this’ and it may lead to something bigger [like] ‘Where would you find crystals? Where do they form?’ you know and that kind of thing” (ICI: 16-18).
Isobel believed inquiry questions were not scientific stating “the type of question that they're asking does not, they’re not science type questions. ‘What can you tell me about this?’ It is kind of a generic thing” (ICI: 25-26). Instead of open-ended questions she preferred more focused questions feeling students would give general answers to a generic question and this would stop the learning. Inquiry could be used as a “kind of icebreaker” in her classes Isobel felt (ICI: 19).

Isobel thought there were specific components required for teaching to occur. There must be “observation occurring” was one condition she required. Quality teachers demonstrated a topic to their student she maintained “are they standing up in front of the class and actually doing it for the students like going along with them?” (ICI: 89-90). She required that instructors talk about a subject, show it, and have students do an activity with the teacher for teaching to occur, and wanted to know “kind of what the background was” before students were exposed to an experiment or demonstration. Isobel required purposeful responses to questions in order for teaching to occur and the questions asked must be focused and “science type questions.” Video must be of high quality to be used as a teaching tool. She queried “Are we talking’ MTV or are we talking’ you know the History Channel or Discovery Channel. That would kind of tell me what kind of quality program that it is” (ICI: 50-51).

Isobel had a few conditions for learning. When questioned, she felt that the quality of response a student had determined the learning. She also required proof of learning as when she declared “I would love to know how those blueberry muffins came out. Did they come out right or not?” (ICI: 187-188) when asked if teaching and learning were happening when students baked muffins. For learning to occur Isobel required a match between the teacher and the age
and cognitive level of the students. She felt that writing stimulated learning and stated categorically “anytime you write on how to do something you’re learning.”

**Orientation to Teaching Science**

Grossman (1990) explained that an orientation to teaching science consisted of “knowledge and beliefs about the purposes for teaching [science] at different grade levels” (p. 9). I felt Isobel’s orientation to teaching science was in the process of changing from process-oriented to guided inquiry-focused (Figure 4-10). Her orientation was driven by her goals for her students and how she perceived their abilities, understanding and learning style. Her process orientation was evidenced by her teaching goals of interest in science and developing skills. This inquiry-based approach was proposed by Magnusson and Palinscar (1995) and “emphasizes the conceptual understandings of science” (p. 44). Her orientation also reflected Isobel’s developing guided inquiry goals of concept understanding, life skills, and excitement for science.

**Goals for teaching**

Isobel had a science goal of students’ understanding concepts which she called science literacy. She related events in a recent class where she felt her goal of understanding concepts was met: “they figured out Combined Gas Law on their own [without] me telling them about it. Because they were able to take what they had learned the day before and pull together . . . They were able to take bits and pieces of the different laws, put them together, that made sense to come up with the Combined Gas Law and understand it before they even saw it” (II4: 13-14, 17-18). Isobel had the students in her environmental science classes read a series of science articles and discuss them. “If they have a basic understanding even if they do not go into this field. . .if they can take up a newspaper and read about medical advances and they can make an opinion poll, this is good or this is bad because of x, y and z then I have done what I am supposed to do” (II3: 202-206).
Figure 4-10. Isobel’s Orientation to Teaching Science.
Another science goal for Isobel was her desire for students to have a career in science. Isobel viewed herself as a guide and spent time talking with her students: “Just asking the kids what they wanted to do; you know kind of guide them to possible schools, scholarships, professors they can talk to types of things ‘cause their juniors so they need to be kind of guided” (II1: 564-566). A third science goal for Isobel was for students to develop science skills. “One of the things that this semester I really want them to do is to do more labs, to get familiar with the different types of equipment, the scientific method, things that work, things that do not work” (II2:147-149).

Isobel had a general goal of life skills for her students. The goal she has set for herself was to help students develop teamwork to “learn to work together.” Isobel noted, “They need to learn how to assist one another. They need to realize that they can not do everything on their own” (II2:90-92).

An affective goal for Isobel was to develop student’s excitement for science which encompassed not only interest but possible careers in science. She talked of her students when they had “seen things in the lab, actually getting excited about things” (II2:164-166) and the importance of student motivation to her.

**Science Curriculum**

Curriculum was important for Isobel. She wanted to provide her students with the full curriculum and discussed concepts already taught: “We’ve covered already states of matter obviously, balancing equations, naming elements” (II1: 389-390) she enumerated. It was important her students “got” the concepts and she was overjoyed when her students told her they were doing well in her class (II1: 353-355). Isobel felt that curriculum must be aligned with standards. “We tie [curriculum] into Sunshine State Standards. We tie it into the homework. We tie everything together” (II1: 230-231) she declared.
The textbook was used as a reference in her class and she found problems from different sections of the book to develop student’s problem solving skills (II1: 299-301). Isobel stated: “I’m not following the book order. I’m bouncing all over” (II1: 516) in her quest to give her students a solid concept knowledge of chemistry. The anatomy and physiology text she declared “too hard for students” and “more on a college level” (II1: 291-293). Other textbooks she declared tolerable but seldom taught directly from them.

School context

Isobel taught at a rural public school in County Three in the center of the state. She instructed in three courses: one section of anatomy and physiology, three sections of environmental science and one section of honors chemistry. Daily she prepared lesson plans and followed the curriculum of these three separate courses. This can be very stressful and difficult for a beginning science teacher but Isobel never directly mentioned this.

Several issues impacted her teaching science. Isobel lacked proper equipment in her laboratory having to order Bunsen burners and other equipment to perform chemistry experiments. The classroom facilities needed renovating as the gas lines did not work when she started teaching and electric power was absent in most lab stations.

Other issues that affect her teaching were the lack of time for lesson planning and high-stakes tests. Isobel commented “I do not plan way, way, way in advance because it is a lot of work and typically you have to redo it anyway” (II2: 141-142). In talking about high-stakes testing in her state she stated “I have looked at the [state high-stakes test for] science and that is kind of scary too considering that these are juniors and some students would like to take chemistry is a senior class and it is already on the [test]” (II1: 573-575).

Two additional factors affected her teaching. Isobel was required to submit lesson plans but was allowed to do so after she has taught the lesson. She related what the administrator told...
her “Look, you can have lesson plans. You can have all you want. We know chances are that's not what’s going to happen. So we want to know what really happened in the class room” (II4: 226-228). Public schools have a policy of the principal observing teachers instructing. Normally this occurs a few times a year but for new teachers, the observations are more frequent.

**Learner characteristics**

Isobel saw her students as very able. “I think they’re very bright however I think they lack motivation” (II2:50-51). She clarified, “They think I should tell them and they should understand it immediately and they should never have to study. . .It is not going to happen” (I2:62-63, 66). She pushed them to work and made them responsible for their own productivity. Many of her students were inexperienced and “have never done experiments before.” Isobel envisioned her role as building student confidence and helping them to succeed. She noted that “a lot of them do not feel that they are smart enough” and used demos and student participation in hands-on activities to increase their confidence.

Student understanding was seen by Isobel as “pulling it together” and she helped them accomplish this by asking questions, performing experiments, with seat work and having them read and discuss articles. “They take the information from the article and they start pulling in personal experiences and their own knowledge and they start synthesizing stuff” (II3: 193-194). She allowed them to make mistakes on their own and shared with me how her students problem-solved, “It taught them to go back and troubleshoot. If that does not make sense, look at your answer. Does that make sense? If it does not make sense, does not match the book, where was your error?” (II4: 82-84).

Isobel perceived her student’s main learning style as group work, especially her male students. As she explained it boys have “the good old boy network. How the boys help one another and girls are like ‘you have to do it on your own’ . . . and they do not help one another”
Lab partnering was another style of group learning Isobel observed. She accepted and even encouraged this observing “if it takes someone else doing it first . . . then so be it” (II2: 248-250) when discussing a recent experiment using air pressure to crush aluminum cans.

Another learning style she discovered was her student’s resistance to writing things down. They, especially the boys, liked to do problems in their head many times getting them wrong. Isobel explained why writing down was so important: “once you see it and you may run through your head but if you have to write it you have to understand what you’re writing” (II2: 217-218).

**Rationale for instruction**

A teacher’s OTS is shaped partially by curriculum and assessment and seen in their teaching strategies (Lantz & Kass, 1987). How Isobel viewed curriculum, plans for lessons and her scheme of assessment, and as well as her teaching style and strategies for teaching demonstrated this. Isobel served on the science textbook committee, and chose all new textbooks for each of her classes next year and was looking forward to teaching chemistry and honors chemistry. When using her current text she remarked, “I’m not following the book order. I’m bouncing all over” (II1: 516). She used the state standards to ensure that she covered all required curriculum but used her content knowledge to guide the curriculum. “I have a textbook to use and I kind of pick and choose amongst that and what they say they need to know and then what I think that they need to know especially if they go on to college” (II1: 551-553).

Isobel had a general plan for her lessons. “I have in my mind what I want to do but when it gets right down to it what actually we’re going to do I kind of do it about 2 or three days at a time” (II2: 133-136). She always allowed an extra day as “a play day” where she can go over concepts which students might have not completely understood. She used print media, video, and the internet in her classes. When searching for articles on technology and medicine, she looked for “two different viewpoints” so that her students were exposed to different ideas, allowing
them to make up their minds. Isobel’s school required teachers to turn in lesson plans but allowed them to be submitted after they are taught as they “want to know what really happened in the classroom” (II4: 228).

One way Isobel assessed student learning was to check student’s formative understanding of concepts. She observed “I can tell a lot of times how well they comprehended something based on their homework and based on the conversation that we have” (II3: 98-99). She employed essays, lab reports, quizzes, and tests for formal assessments and also used something she calls exit tickets for more informal assessment:

“sometimes before the kids are allowed to leave the room they have to write an exit ticket and what an exit ticket will entail is they have to tell me something that they learned and possibly have a real quick example or write an example in words or use the formula to describe it” (II3: 106-109).

All assessments were used in calculating student’s grades. Isobel saw testing as extremely important and worked to prepare students for this assessment. One way she accomplished this was by having students “make up a five point or a five question quiz based on information that they have and they have to attach a separate answer sheet” (II4: 295-297). Students then swapped quizzes and took someone else’s hand-made quiz. “That way not only did they do their five but they did somebody else’s five. And they can pull things together” (II4: 300-301) she explained.

**Instructional strategies**

Various strategies made up Isobel’s teaching techniques. She utilized questioning, story problems, demos, activities, labs and discussion to keep her classes lively. In a recent class she felt that the demo at the end was important “because it brought everything together and it culminated [in understanding] because they thought about what they did and they were still really unsure themselves” (II3: 41-43). Labs were especially important to Isobel as it taught her
students to work together. “It helps if someone’s doing it, someone is writing it down then switch so that way if you had a problem the first time, the second time ‘Oh, now I see what we did.’ It is repetition. They have to do it twice.” (II2: 93-95)

She applied technology as a teaching tool, stating “I go through and I’m like ‘Okay, what are the basic things I need them to know’ and I go through and I pull everything out and I make PowerPoint slides and I say ‘in reference, turn to page so-and-so and you an see a picture’” (II1: 310-313). Isobel also used video to illustrate her lessons. She employed modeling as a teaching strategy explaining “I purposely make mistakes when I’m speaking, on the board, when I spell so they realize ‘Oh, well … everyone makes mistakes.’ Just as long as you correct them it is OK” (II2: 105-107).

Isobel’s teaching style was informal and enthusiastic, with her telling stories to her students to illustrate concepts or her difficulties with problem-solving. “I do not stand behind the podium because it is a small class. I usually walk around the room, walk amongst them”, she averred. She expected students to be responsible for their knowledge commenting “It is your responsibility. You need to learn it. You need to grab hold” (II2: 69). About her storytelling: “the stories help them relate to what we’re doing or maybe if they don’t understand something ‘Oh well. She’s been through this. She understands’” (II2: 112-114). About science teaching, Isobel felt “we’ve got to start off basic. It works best.” Her philosophy was simply stated “It wasn’t about the answer. It was about the process because the answer was already there” (II4: 88-89).

George

Introduction and School Setting

George was in his early twenties teaching science at a private pre-kindergarten through twelfth grade school in Bay, a suburb of a large coastal city in County Four. He earned a Bachelor of Arts degree in environmental science from a southeastern university in 2003 but had
no teaching degree. George was working toward becoming alternatively certified and was required by his school to take three education courses and pass his subject area and teacher professional competency exams.

Being an environmental science major his course work was in on geology and geographic information systems but general science course work was focused in physics, his favorite subject. George took several education courses on child development, child psychology and teacher development.

He was a laboratory research assistant for six months after attaining his degree where he performed all tests and analyzed all of the data using his extensive GIS background. George became a teacher because:

“I’ve always kind of enjoyed science and so as far as teaching goes that would be the most natural subject for me to teach. My degree’s in environmental science . . . there’s always more hands-on things possible to do. It is not always the easiest in earth science to find big you know monumental experiments but there’s always little things, demonstrations or activities you can do.”

George taught seventh grade earth science and an upper school elective called vertebrate biology at Bayside Country Day School in Bay. The private non-sectarian school had a student population of 758. The student body was comprised of white (91%), African-American (5%), and Asian and Hispanic (4%) students. There were 80 teachers with an average of 15 years of teaching experience, over fifty percent with advanced degrees.

**Classroom Setting**

George's school was located in a large fairly new complex tucked into a wooded area. Behind the upper school there was a block of rooms designated the middle school. George’s room appeared large and more wide than long. There were two rear doors, one on the left wall
and one on the right wall which led to the outside.

A large counter was mounted along the left wall with three chairs underneath. Three iMacs with keyboards and mice sat atop the counter. Shelves stretched above the counter the full length of the wall. The left pair of shelves by the door held test tube racks in the top shelf and videos in the bottom. The rest of the shelves were filled with books. Along the rear wall hung three canvas and plastic goggle holders with student lab goggles placed in them. Against the wall next to them stood a two-person student desk with two posters depicting the experimental method mounted above.

Two-thirds of the way to the right rear door along the rear wall sat a large blue door. Inside revealed a storage room with shelves floor-to-ceiling on all three walls. Lab supplies and equipment rested on the shelves. Out of the supply room along the right wall two double windows were located high up. Below the windows the wall space was decorated with pictures and posters. A ten-inch bulletin board hung below the windows and straddled them containing various posters and pictures of planets and scientists. Book bags, rolled up posters, books and a microwave sat atop a long blue three-shelf bookcase. The shelves were empty. Against the rear wall by the door stood a black metal file cabinet with a landform model atop it.

Along the front wall on the left a bulletin board was mounted on the wall with various notices attached. Directly below it was a blue plastic container with clothing items filling it; probably functioning as the class area for lost and found. Next to it stood two metal filing cabinets, one gray and one cream colored. There was a clutter of objects atop the file cabinets including a poster, a brown paper bag, tissues, and a globe.

Next to the file cabinets stretched a dry erase board sixteen feet long with class assignments written on it. A screen was mounted above the dry erase board. The teacher desk
which doubled as a demonstration table sat in front. Another desk next to it housed an iMac computer, two or three buckets of pens and markers and various papers. A first aid kit was mounted on the front of the teacher demo table and an eye wash station sat to the right of it. Above this a television mounted on the wall was tuned to a sports channel. A cartographic map of the world dangled below the TV. The room was filled with six four-person tables and one two-person table and chairs were grouped around the tables.

**Conception of Teaching Science**

George had a student-centered conception of teaching science (Figure 4-11) with several parts including teachers and teaching, instructional strategies, science, learners and learning, and conditions for instruction.

**Teachers and teaching**

George saw teachers as guides, using their personality to teach. When talking to students about geothermal power he commented, “Iceland, I’ve actually been there too so I got to tell them some good stories about burning myself in the shower and stuff” (GCI: 37-38). He additionally conceived teachers as having the ability to teach at a specific grade or cognitive level and having an interest in the subject matter. He could not see professors as being able to teach to a younger, less interested group and stated “I can pretty much guarantee that if any of my college professors came into any of my classes here that I teach you know any of my earth science classes I do not think any teaching would really go on” (GCI: 76-79). George explained that a professor’s teaching style was “just not as conducive to this level of student or level of interest” (GCI: 85-86).

There could be no teaching without learning George understood. For learning to occur teaching must happen and he called it “a sort of two-way process.” Concept development was very important to him. When talking about an inquiry activity with rocks he stated:
Figure 4-11. George’s Conception of Teaching Science.
“it is kind of getting’ the kids to go beyond just what they normally see in rocks and more than just like the color you know that it is big or heavy or whatever so they're looking at more of the texture or hopefully looking at more than just the initial thing so they’re starting to think about rocks as more than just you know what they normally thought of it as.” (GCI: 22-26)

He perceived many teaching activities such as self-study, group work, teaching others and using different mediums as possible methods of teaching. When talking of the possibility of teaching by video he averred “there’s definitely teaching going on even though it is not an actual person” and defends his position further commenting “just because it is a TV show does not mean that it is not educational so it is just a different medium” (GCI: 44-45).

George supported inquiry and used real-world examples in teaching for conceptual change as evidenced in a discussion with his students:

“we talked about that FedEx commercial from the Super Bowl with the pterodactyls or whatever— because a lot of the kids really liked it – and I was like ‘that commercial really bothered me’ and then asked them if they knew why it really bothered me. What was really wrong about it from a science standpoint and . . . most of the kids thought like the whole cartoon thing that caveman ate dinosaurs and they did not know that the Flintstones was not like a biography of some of it so they thought that that was historically accurate” (GCI: 182-183, 185-192, 195-196).

When I asked him how he would deal with these misconceptions, he outlined a discussion session about the geologic time scale and declared “Dinosaurs and humans are separated by a few million years which I think is pretty easy grasp [for student understanding]” (GCI: 214-215).
Instructional strategies

George had a well-defined set of teaching strategies. He used inquiry as a chance of “getting’ the kids to go beyond just what they normally see” and develop deep concept knowledge. George used storytelling as a learning and motivation tool and spoke of his travels to his students. He stated “we actually just finished up with tectonics plates and we were talking about Iceland. They . . . use geothermal power . . . to heat their homes and stuff” (GCI: 35-37).

George supported interdisciplinary teaching especially using mathematics as he felt that “it is a practical real-world, everyday kind of thing and . . . I think math is a tool that is, and should be commonly used in the sciences” (GCI: 108-109). Other techniques he used were student group work, as well as projects and labs. He supported “different sorts of environments and different mediums” such as video in his teaching as well as using diagrams and visuals. George relied on his LCD projector in class but since it malfunctioned he started drawing diagrams on the chalkboard and using balls, Slinky’s, and jump ropes to demonstrate the concepts he teaches.

Conceptions of science

George saw science as a body of knowledge used to explain phenomena. He was comfortable with science content, his speech interlarded with scientific terminology. George was concerned that students not just learn the material but tie concepts together and clarifies with concerns of student memorization: “If they’re not learning something else to go along with it is not going to be useful for science” (GCI: 169-170). He understood the concept of student misconceptions and preconceptions and mentally formulated plans for debunking them but did not express his views on the nature of science or the impact that science has on man or the environment.
**Learning and learners**

George viewed students as being able to learn from media, from teaching each other, from social learning and self-learning. He realized that an “actual person” does not have to be present for teaching or learning to occur (GCI: 39-40). George stated that “sometimes the best way to learn something is to actually teach it” (GCI: 58-59). He appeared to support a constructivist approach to learning averring “some [students] may get some things better than other things and then the person they’re working with may get those things that they do not get so well” (GCI: 62-64). George was very concerned about concept building and stressed he wanted “kids to go beyond what they normally see” when talking of inquiry activities (GCI: 23). He commented that memorization was not learning “it is just asking to have something reproduced from memory” but laughingly comments on his students dependence on it by observing “the kids love telling me that memorization is in a method of learning” (GCI: 165-166).

George realized differences in specific populations of learners and appeared to understand his students, their interests and motivations. In class he worked with his learners to interest them, using storytelling, diagrams, manipulatives, and other devices to trigger learning. George knew the knowledge and skills level of the students he taught: “kids typically do not have much of a grasp on weather or anything at this point” (GCI: 106-107) and maintained “I can guarantee you that most kids could not properly work a triple-beam balance.”

He looked at a student’s age and cognitive level when examining teaching and learning. When talking of a particular scenario he declared “this particular example would be over the level of first-graders and probably be on the level of most middle school kids, depending on I guess how you taught it” (GCI: 89-92). He had confidence his students could transfer skills between disciplines and stated “it should not be that much of a stretch for the kids to apply math
skills in a science class” (GCI: 99-100). Finally George recognized that students come to class with preconceptions and misconceptions which have to be dealt with.

**Conditions for instruction**

George had clear conditions for teaching. He saw the possibility of teaching without interaction but felt “it may not be ideal” (GCI: 47-49). George believed teaching could occur with students working together. “I encourage them to work together on their homework and really any out of class assignments and sometimes some in-class stuff” (GCI: 56-57) he added as he felt one of the best ways to learn something is to teach it to others. George felt that teaching would only occur in the presence of learning and stated “I do not think any teaching would really go on” (GCI: 76-79) when asked about a particular teaching scenario.

One of the most important conditions for teaching to George was the intent of instruction. George asked “what is the purpose” for a particular activity and “what the intent was” for a self-study guide (GCI: 248-249; 284). He saw self-study as important and something that could be used for science teaching but stated “that’s not really teaching” (GCI: 292).

George had few conditions for learning. He was concerned that misconceptions could block learning especially with a long-held misconception such as the dinosaur and humans time scale separation. George believed that concepts must be tied together else “there’s nothing behind it. If they’re not learning something else to go along with it it is not going to be useful for science” (GCI: 169-170). Finally he believed that memorization was not learning and had a strong bias against it.

**Orientation to Teaching Science**

I feel that George’s orientation to teaching science, what Grossman (1990) explained consisted of “knowledge and beliefs about the purposes for teaching” (p. 9) was project-based, (Figure 4-12) and driven by his goals for his students and how he perceived their abilities,
Figure 4-12. George’s Project-based Orientation to Teaching Science.
understanding and learning style. This project-based approach was proposed by Marx and his colleagues (1994) where “teacher and student activity centers around a ‘driving’ question that organizes concepts and principles and drives activities within a topic of study” (Magnusson, Krajcik and Borko, 1999, p. 16). This reflected George’s goals of students developing concept knowledge, developing their life skills, and generating excitement for science.

**Goals for teaching**

George had several science goals for his students. He enjoyed telling stories, the route by which he illustrated concept knowledge stating, “I like to give them examples, if not from my life then hopefully something from their lives that I can maybe relate back to whatever we’re doing” (GI2: 5-7). George was constantly attempting to show his students that science was real-world, storytelling and explaining the function of science objects. “I just kind of want them to get an idea of how things around them work” (GI2: 15-16) he stated.

His primary general goal and one he was focused on was student academic success. “I try and get them out of this mediocre you know average is the best of the worst. That’s all right but you know it is best of the worst but it is also the worst of the best” (GI1: 265-266) telling the story of his rise in high school from a C student to a straight A, all-state in a couple of sports by his graduation. A second general goal was to teach students life skills declaring, “I want them to actually think instead of just falling into these patterns and things which they do a lot of” (GI1: 307-308).

An affective goal for George was to promote student’s excitement for science, to “try and keep their interest but still give them as much facts and things as I can so they will be prepared” (GI1: 74-275) for possible careers in science which was another goal. He reiterates, “I try more, I try really hard to keep or get them interested in school” (GI1: 260-261).
Science curriculum

Curriculum was important to George and he discussed the concepts he covered in class: “We’ve gone over weather and general science practices, the basic landforms, mountains, erosion and deposition, plate tectonics and continental drift, sea floor spreading, then we’re going to go to space and cover the solar system and all the planets” he elucidates (GI1: 366-369, 371-372). The curriculum for his earth/space science class was aligned with a past teacher. George explained, “I have basically the curriculum that they used last year” (GI2: 244). He used the textbook as a reference when teaching “I use the book as my guide … I sort of follow the progression in the book” (GI2: 233-234).

School context

An urban private school in County Four was the location where George taught. The school was secular and considered a college preparatory academy for students in kindergarten through 12th grade. He instructed 7th grade students in earth and space science and juniors and seniors in vertebrate biology.

Certain teaching issues had an impact on his teaching. George had a large equipment and supplies cabinet to the rear of his room. Unfortunately, the contents of the cabinet had not been inventoried nor had the use of many pieces of equipment been explained to him. This made the equipment unusable and materials unorganized and difficult to locate. George preferred using technology when he taught but his LCD projector which hooks to his computer had been broken for over a month and he had to use dry erase boards, diagrams, and manipulatives to teach instead of his PowerPoint slides and internet sites. Another issue was his lack of time to lesson plan. George discussed lack of preparation in an interview: “well I had to do some grading and stuff today so I really was not able to plan for this lesson” (GI4: 202-203). This happened frequently to him.
Learner characteristics

George taught 7th grade science and saw his students as having ability but lacking maturity and life experience. Being a special needs student himself he recognized that he had many exceptional students but felt some might be wrongly labeled:

“there are a lot of kids in this class that get diagnosed because they do not do well in school or because they are having other issues or because you know they are just middle schoolers and dealing with everything. There are probably a few that actually need those sorts of special needs and things.” (GI2: 122-125).

He had a wide range of abilities in his classes as he taught the entire 7th grade in his private school. “The classes are really different so I kind of have to treat them differently but as far as the material I covered it was not much different” (GI2: 270-271) he commented. Some of the classes were difficult discipline-wise which caused students in those classes to lag farther behind and have the ability to tie things together. George believed of these students that “they knew less about [the topic] because they were not able to make those connections” (GI3: 139-140).

Another issue was student focus on grades and their particular roles and stereotypes. George related, “you hear them all the time, ‘Oh, he’s the smart kid. I’m the stupid one’” (GI1: 311).

Student understanding was viewed by George as “starting to connect the dots” and he helped them accomplish this by asking questions, performing demonstrations, lecturing and discussing, and having them use the internet to research a real-world topic:

“we started out doing the general stuff and then hurricane Katrina started bearing down on us so we switched over and started doing weather and hurricanes in particular. Katrina ended up being a really big storm and it ended up being really good for lots of material to study and there was always stuff to look up and show things from the internet” (GI1: 92-94, 97-100).
This became a several week project and at its culmination George printed a 60-page booklet for his students of all of the hurricane information they had amassed. Final task consisted of students writing a two or three page essay on what they’d learned.

George worked all year to change his student’s main learning style of memorization adding “they just do not seem to be able to adapt very will if I do not just let them memorize” (GI1: 252-253). His students were visual and he liked to draw diagrams on the board, use PowerPoint presentations and display pictorial information and web sites from the internet.

**Rationale for instruction**

George’s orientation for teaching science was shaped partially by curriculum and assessment and seen in his teaching strategies (Lantz & Kass, 1987). How he viewed curriculum, lesson plans and his assessment scheme, as well as his teaching style and strategies for teaching demonstrated this. George used the curriculum set up by a former teacher and was not forced to follow any standards in his private school. He stated he “follow[ed] the progression of the book” and used the curriculum that the teacher before him taught.

Lesson planning was straight-forward also for him. George taught the “basic stuff” of geology and his content knowledge is such that “the stuff in the book is so elementary that it is not really even worth going over” (GI3: 234-235). He made himself “a page of notes just to make sure” he knew what he was teaching that day and when his LCD projector was working, made up a PowerPoint presentation of the topic. His comfort with the material was such that he shared, “I will look at it just to make sure I got it all straight maybe and then I will usually go into the more complex things that I remembered that were maybe a little more interesting that I can talk about to them” (GI3: 235-238).

George allowed an extra day or “enough space into my syllabus and things” (GI2: 235) where he can get off topic. He used video and technology in his classes when it was working
properly. As George described: “I usually do a lot of cut-and-paste and things so that I can click on something and it will go to a web site or I will just have them minimized up on the screen and ready to go so I can just bring it up” (GI3: 74-76, 78).

Most of George’s assessment consisted of testing his student’s understanding of the concepts he taught. He used essays, projects, and tests for formal assessment. George used pop quizzes to assess formative knowledge and keep students on task:

“It is both ‘cause I give it to them as a management tool from the fact that if they’re not paying attention or anything then . . . That is why I give them pop quizzes as opposed to regular quizzes. It kind of keeps them a little bit more on their toes, the fact that they have this and they know that they pretty much are going to get a pop quiz” (GI3:301-305).

**Instructional strategies**

George’s teaching strategies consisted of questioning, classroom management, demos, activities, labs, projects, lecture, and discussion. Classroom management was hard to balance with pre-teens and he commented, “I usually try and give them a little bit of leeway because I find a lot of times when you try and be more strict it just ends up being a tug of war or like butting heads” (GI3: 191-193). Earth science activities for students were hard to find: “It is not always the easiest in earth science to find big you know monumental experiments but there’s always little things, demonstrations or activities you can do” (GI1: 75-77).

Technology was used as a teaching tool by George when his LCD projector was not broken. While it was being fixed he diagramed the different geological fault types on the dry erase board and used manipulatives to show the forces of land formation. “I just like to be able to give them as much as possible so that they can visualize the way that the faults move and things,” (GI3: 17-18) he stated.
George had an informal teaching style, telling stories to his students to illustrate concepts or to teach them life skills. He liked to give his students background taking a couple of days to “kind of get through the nuts and bolts like the meat and potatoes and then we can go and we can do something or we can go back and discuss a little bit more beyond just the homework and things” (GI3: 215-217). He felt it important for the teacher to “demonstrate you know what you’re talking about” so students would listen to the instructor (GI3: 238-240). “I try and mess around with them as much as possible” (GI2: 167) George commented. Having been classified as a student with special needs, he tried to present the material in different ways especially having “a lot of those visuals” to keep them interested (GI3: 63-65). Questioning was used by George as a focus because he believed teaching and classroom management went together.

Summary

The six beginning secondary science teachers in this study had specific beliefs and goals about teaching science derived from varying sources. The researcher has attempted to describe and represent the beliefs and goals of these new teachers found in their conceptions of teaching science and orientations to teaching science in this study.
CHAPTER 5
CROSS-CASE ANALYSIS OF PARTICIPANTS’ CONCEPTIONS OF AND ORIENTATIONS TO TEACHING SCIENCE

Background

Six beginning secondary science teachers in their first year of teaching were observed and interviewed to learn their Orientations to Teaching Science, defined as a teacher’s knowledge and beliefs about the purposes and goals of teaching science (Grossman, 1990; Magnusson et al., 1999). At the same time, I observed and interviewed these beginning teachers to discover their Conceptions of Teaching Science consisting of their conceptions of the particular content to be taught, the particular students they will be teaching, and effective instructional strategies to plan and perform to achieve the intention of helping these students learn the desired content” (Hewson & Hewson, 1988, p. 611). A multiple case studies model was chosen to fully describe the six cases from the data, and a cross-case analysis was accomplished to illustrate the similarities and differences between them (Merriam, 1998).

I first performed within-case analysis examining the data collected for each participant (see Chapter 4). Second, I completed cross-case analysis using comparative analysis to yield similar and discrepant cases which were used to form general explanations amid the cases of the beginning secondary science teachers. Three research questions guided my exploration of similarities and differences in conceptions of teaching science, orientations to teaching science and the possible sources for those orientations: (1) what are the conceptions of teaching science of the six beginning secondary science teachers in this study, (2) what is the nature of orientations to teaching science of the six beginning secondary science teachers in this study, and (3) to what extent does CTS and OTS help elicit beginning science teachers thinking (PCK)?

In this chapter, I present a multi-case analysis highlighting the similarities and differences in these participants OTS and CTS.
Comparisons between Components of Conceptions of Teaching Science

Teachers instruct students in particular science classes based on “conceptual structures” they have built “in which they incorporate classroom events, instructional concepts, socially approved behaviors and explanatory patterns (Hewson, Kerby & Cook, 1995, p. 505). These conceptual structures, called conceptions of teaching science are “[a] set of ideas, understandings, and interpretations of experience concerning the teacher and teaching, the nature and content of science and the learners and learning which the teacher uses in making decisions about teaching, both in planning and execution” (p. 194).

A teachers’ understanding of how to teach a specific science subject to a particular group of students encompasses every aspect of their teaching from choosing what activities and demonstrations to use to the explanations they employ when teaching particular topics. Different teachers have their own beliefs about students, teaching, and science, leading to each educator’s unique CTS.

I evaluated similarities and differences between the conceptions of teaching science for each of the beginning secondary science teachers. Seven components, that is, teacher characteristics, teaching, conceptions of science, learning, learner characteristics, conditions for instruction, and preferred instructional techniques, (see Figure 5-1) were suggested by the data, modifying Hewson and Hewson’s (1989) six categories as were discussed in chapter 3. This cross-case analysis compared all of the components of CTS between the six participants as Hewson and Hewson (1989) suggest.
The seven components of participant’s conceptions of teaching science are discussed below in each of the subsections. At the beginning of each subsection the reader will find the definition of that particular component.

**Teacher Characteristics**

Teacher characteristics are a participant’s beliefs about teachers including knowledge, training, skills, personality, and attitude needed to teach. Using Hewson and Hewson’s (1989) task for determining Conceptions for Teaching Science to examine teachers’ understanding of conceptions of science I interviewed all six participants. Data were analyzed for each participant and categories created to organize their responses. Looking across the “cases” two larger

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<table>
<thead>
<tr>
<th>Teacher Characteristics</th>
<th>Conceptions of Teaching</th>
<th>Conceptions of Science</th>
<th>Conceptions of Learning</th>
<th>Learner Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beliefs about teachers including knowledge, training, skills, personality, and attitude needed</td>
<td>Beliefs about teaching include how teachers teach, textbook use, and use of inquiry, media and student self-teaching</td>
<td>Beliefs about what science is made up of and how it is used, and the nature of science</td>
<td>Beliefs about learning including definition, whether teacher needed to learn, learning from media</td>
<td>Beliefs about learners including their prior knowledge, motivation, ability, age and cognitive level</td>
</tr>
</tbody>
</table>

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### Figure 5-1. Components of participant’s Conceptions of Teaching Science (Modified from Hewson & Hewson, 1989).

- **Teacher Characteristics**
- **Conceptions of Teaching**
- **Conceptions of Science**
- **Conceptions of Learning**
- **Learner Characteristics**

**Conditions for Instruction**
- Beliefs about what is needed for teaching, quality of teaching materials, and other factors

**Instructional Strategies**
- Beliefs about techniques needed for successful teaching including textbook, activities, and presentation
categories emerged: general teacher characteristics, and ability to teach at different cognitive/age levels. A definition for each category is presented in the corresponding subsections below. The summary of each participant’s conceptions of teacher characteristics is summarized in Table 5-1.

Table 5-1. Participant’s conceptions of teacher characteristics.

<table>
<thead>
<tr>
<th>General Teacher Characteristics</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Christina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to Teach at Different Cognitive / Age Levels</td>
<td>Teachers as source of knowledge</td>
<td>Teachers as guide pose questions</td>
<td>Teachers as source of knowledge make “personal connection with the students”</td>
<td>Teachers as source of knowledge should love subject they teach</td>
<td>Teachers as source of knowledge &amp; know what’s going on</td>
<td>Teachers as guide use personality and knowledge to teach</td>
</tr>
<tr>
<td>“Trained” teacher can teach at different cognitive /age levels</td>
<td>“Trained” teacher can teach at different cognitive /age levels</td>
<td>Need trained teacher and book at specific level</td>
<td>“Good” teacher can teach at different cognitive /age levels</td>
<td>Not conducive for teacher to teach at different levels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**General teacher characteristics**

General teacher characteristics are how each participant “sees” or conceptualizes the teacher. I found that Patrick, Alex, and Cristina conceptualized the teacher as the source of knowledge in the classroom. Patrick stated that for teaching to be happening the teacher was “asking what happens because you know what happened prior…posing a question…you want [students] to think about it and either look it up or recall information that you’ve taught” (PCI: 210-212, 214-215). Alex also perceived teachers as the source of knowledge finding student knowledge and teaching from that point (ACI: 47-49). This view of the teacher relates to Boz and Uzantiryaki’s (2006) traditional conception of the teacher as the authority figure who controls students.

Patrick and Isobel believed that a teacher needed formal training and experience. Patrick explained how a college professor could teach first graders: “I mean that’s her specialization,
bringing it down to all levels. So it can be done” (PCI: 166-167). Isobel also felt a teacher must be knowledgeable in order to teach effectively stating “they have to understand, they have to be knowledgeable, and they have to know what’s going on” (ICI: 214-215). All other participants did not specifically comment on training and experience.

Both Meredith and George viewed the teacher as a guide, a constructivist view of teaching (Boz & Uzuntiryaki, 2006). George mentioned, “I was able to make some jokes and things that like I think kept them more interested” (GI4: 33-34) using personality as a teaching strategy. Meredith talked of modeling her mentors stating “I thought they did a good job for me so obviously they were doing something right” (MI1: 118-119). She also felt that good teachers “made that personal connection with the students” (MI1: 125).

Teacher personality and attitude was discussed by four of the participants. Alex felt that the teacher must love the subject they were teaching. He commented “it does not matter … I could teach that and I could excite them” (ACI: 146-147). Cristina and George believed that a teacher’s personality determined whether they could teach effectively. “I think a college professor depending on their personality can alter any subject to whatever age group,” Cristina stated (CCI: 117-118). Meredith felt a good teacher made a personal connection with students.

**Ability to teach at different cognitive/age levels**

Participants held differing beliefs of whether a teacher could teach only at a single cognitive or age level or at all ages and levels depending on their training, experience, or the quality of their teaching. Isobel and George believed the teacher had the ability to teach at a specific level and questioned whether a professor could teach on a low enough cognitive level for young students. Isobel stated, “if he can break it down to where six-year olds can understand that, the man’s a genius” (ICI: 78-79).
Alex felt that not only does a teacher teach at specific levels but the requisite text was also needed to teach children at different age and cognitive levels. “I’d probably rip the college professor out and put an elementary school teacher in there and I would have to find a book down to that level” when discussing whether a college professor could teach first graders (ACI: 126-128).

Patrick, Meredith, and Christina believed that a professor could teach any level depending on specialization, training, or whether they were “good.” Patrick averred “a college professor can do it… that’s a specialization, bringing it down to all levels” (PCI: 164, 167-168). Meredith wanted to know “if the college professor is experienced with speaking to first-graders or if he’s accustomed to speaking to college students” (MCI: 90-91) when deciding whether they could teach first grade students. Cristina stated, “If they’re a good teacher he can take any subject and teach it in a way that first graders can understand” (CCI: 118-120).

**Conceptions of Teaching**

Participant’s beliefs about teaching include how they teach, textbook use, and use of inquiry, media and student self-teaching. Using Hewson and Hewson’s (1989) Task for determining Conceptions for Teaching Science, I interviewed all six participants. Data were analyzed for each participant and categories created to organize these responses. Looking across the “cases” five larger categories emerged, that is, General Conceptions of Teaching, Use of Textbook, Use of Inquiry, Teaching from Media, and Self-teaching. A definition for each category is presented in the corresponding subsection and a summary of each participant’s conceptions of teaching are summarized in Table 5-2.

**General conception of teaching**

An overarching belief about how teachers instruct comprises a participant’s general conception of teaching. In a study by Porlan and del Poso (2004) of teachers’ conceptions of
teaching science, Gallagher’s (1993; 2004) six types of viewpoints they held about teaching.

They were that teaching was 1) the transmission of knowledge, 2) the organization of science

Table 5-2. Participant’s conceptions of teaching.

<table>
<thead>
<tr>
<th>General Conception of Teaching</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Cristina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching is knowledge transmission and starts with questions</td>
<td>Teaching is knowledge transmission and starts with questions</td>
<td>Teaching is knowledge transmission and starts with questions</td>
<td>Teaching is knowledge transmission and starts with questions</td>
<td>Teaching is Interactive and hands-on “show ‘em, have ‘em do it”</td>
<td>Teaching not possible without learning “two-way process”</td>
<td></td>
</tr>
<tr>
<td>Use of Textbook</td>
<td>Textbook used for illustrating; assigned work</td>
<td>Textbook used for planning and reference</td>
<td>Teacher can only teach what book says</td>
<td>Could not teach without using book</td>
<td>Textbook used in class for problem solving</td>
<td>Textbook used for illustrating; assigned work</td>
</tr>
<tr>
<td>Use of Inquiry</td>
<td>Inquiry is not guided enough for teaching</td>
<td>Uses inquiry to ‘sneak the learning in’</td>
<td>Inquiry is a great start - need to teach subject first</td>
<td>Inquiry is too open-ended, a starting point</td>
<td>Inquiry is a kind of opening icebreaker</td>
<td>Uses inquiry with geology classes</td>
</tr>
<tr>
<td>Teaching from Media</td>
<td>Can teach from good quality media</td>
<td>Can apply current topic to teach with media</td>
<td>Teaching from media not “total teaching”</td>
<td>To teach from media must see evidence of learning</td>
<td>Can teach from media if there is student interest</td>
<td>Media just a different medium for teaching</td>
</tr>
<tr>
<td>Self-teaching</td>
<td>Self-teaching is students working together at a task</td>
<td>Self-teaching – ‘can relate just about anything to science”</td>
<td>Self-teaching not total teaching – “borderline on this”</td>
<td>Self-teaching only occurs in certain instances</td>
<td>Self-teaching is student grasping concepts</td>
<td>Self-teaching only occurs in certain instances</td>
</tr>
</tbody>
</table>

content, 3) a set of manipulative activities, 4) a learning cycle, 5) conceptual change, and 6) a guide through a constructivist process. These viewpoints are helpful in aligning my six participants’ general conceptions of teaching.

Three new secondary science teachers, Patrick, Alex and Cristina, conceived teaching as knowledge transmission. Patrick saw teaching as “It puts something in front of you and asks a question” (PCI: 76-77). He believed the teacher led the discussion “to get the questions rolling”
Cristina viewed teacher questions as the beginning of “active teaching” where the teacher was in front of a classroom full of students and led the learning. “Kind of for me teaching is active teaching” (CCI: 191) she explained. Alex perceived teaching as finding out what students knew and telling them what they needed to know (ACI: 222-223).

Both Isobel and Alex viewed teaching as a set of manipulative activities (Porlan & del Pozo, 2004), both calling it hands-on. Isobel explained her vision of teaching as three-fold: “So are you saying it and then showing them and having them do it with you so not only do they hear it, they see it but then they do it” (ICI: 90-91). Alex also believed in hands-on teaching but felt teaching must precede the hands-on component (ACI: 158). Both teachers liked to use demonstration and activity on a daily basis to explain and cement the learning occurring in their classes.

Meredith and George believed that teaching was not possible without learning, having the teacher as a guide through a constructivist process (Porlan & del Pozo, 2004). When asked if a professor were teaching when lecturing first graders on Darwin’s Theory of Natural Selection Meredith felt that teaching was occurring but not learning. “Lecturing probably is not going to work as much as having then do something like looking at fish and saying what happens when you know the predators come to eat the fish and then they can visually see happening” (MCI: 106-109). George saw teaching as a two-way process with students interacting with the teacher (GCI: 79-80). He stated, “I mean really any way that you can get students to think about or apply any kind of knowledge, especially scientific knowledge causes them to learn” (GCI: 117-119).

**Use of textbook**

Use of textbook is defined as whether a teacher uses a textbook to teach from or just as a reference in teaching. Two participants felt that a textbook was needed for teaching. Alex and
Cristina believed the teacher needed to teach out of a book. Alex stated, “you can only teach what the book says to teach” (AI1:185) and followed the chapters in his text mostly in sequence. “I could not teach without a textbook obviously” (CI1:384) Cristina averred.

Patrick, Meredith, Isobel and George used books in class as references. Patrick used the book as a visual aid stating “They might not be able to visualize it without some other aid or whether I say you know, open to page hundred and two in your book. Follow along in the diagram” (PCI: 187-189). Meredith in an interview explained her classroom textbook use as a resource for completing seatwork or activities (MI4:207-208). When observing Isobel and George I noticed they would also direct students to information in the book or to use for completing activities but they did not teach directly from a particular chapter.

**Use of Inquiry**

Whether a teacher uses inquiry for teaching and how they use it is another ingredient of participant’s conceptions of teaching. Inquiry is a form of teacher-supported, student-centered instruction characterized by students defining problems and investigating them, drawing conclusions, and determining the whether their conclusions are correct (Magnusson, Krajcik & Borko, 1999). Both Meredith and George conceived inquiry as a form of teaching. George viewed the inquiry process as concept development or “kind of getting the kids to go beyond just what they normally see” (GCI: 22-23). Meredith saw inquiry as “sneaking knowledge in” when students were hesitant about learning. She commented “if you can get [students] to learn something without them knowing their learning then there's a good chance they will retain it (MCI: 25-26).

Four participants felt that inquiry could only be used to start teaching. Cristina believed that with inquiry open-ended questions were not focused enough for learning and lacked what she termed active teaching. She added, “I use inquiry kind of like open-ended inquiry like that at
the start and then I begin my teaching” (CCI: 47-48). Isobel, like Cristina, envisioned inquiry as “just kind of an opening icebreaker to get you to start talking” (CCI: 19) with the questions too unfocused. Alex also saw inquiry as “a great start to let you know…what knowledge level the kids already have” (ACI: 24-26). Patrick felt that the open-ended questions which characterize inquiry were too vague. He believed that the learning should be framed prior to inquiry and stated, “maybe okay we will do a little something beforehand or even just a worksheet quick synopsis” (PCI:58-60).

**Teaching from media**

Media in education represents many different presentation formats for instruction including films, filmstrips, and web sites and participants had viewpoints on the whether teaching could occur from media. Four participants felt that teaching could be accomplished with media. Meredith supposed that a conscious decision by students was made “because they’ve chosen to watch this [and] they will probably be more receptive to the information there” (MCI: 50-51). She believed moreover that the questions used to focus viewing of media allowed teachers to use even popular media like “The Little Mermaid” to teach concepts. George asserted, “I think its good to be taught and to learn from different sorts of environments and different mediums’ (GCI: 33-34) and added “just because its a TV show does not mean that it is not educational” (GCI: 44-45).

Patrick and Isobel also believed that teaching could be accomplished through video but were concerned that the program be educational. For Patrick, his concerns focused on “what the actual program was. Who produced it? If it was produced by Hollywood; if it was produced by National Geographic or NSF you know, any, any one of these” (PCI: 103-105). Isobel concurred with Patrick. “Are we talking’ MTV or are we talking’ you know the History Channel or
Discovery Channel. That would kind of tell me what kind of quality program that it is” (ICI: 50-51) she maintained.

Both Alex and Cristina were hesitant that media could be used for teaching. Alex felt that his students could not get much from “the TV” (GCI: 54, 56-57). He additionally needed proof learning was occurring and “would quiz the students” (ACI: 65-66). Cristina felt media could be used in the presence of the teacher but she needed to ascertain if students were paying attention. “The one’s that are [actively participating] when I’m showing the videos the ones that are learning from the videos and video’s teaching them they will go “Miss ___, did you hear that? Did you see that? That’s so cool! I did not know that” (CCI: 84-87).

Self-teaching

Self-teaching is defined as whether students can teach themselves or others without a teacher present. Three participants believed that self-teaching could occur. Meredith claimed: “you can relate just about anything to science” (MCI: 202-203). Isobel explained her thinking: “first of all the student is grasping following methodology to a T and if you do not, what the repercussions are going to be.”(ICI: 182-183). Of baking as self-teaching Patrick said, “They have to mix chemicals together, compounds together and they are reading, they are following directions, they are going to have a product at the end that’s different from what they started with” (PCI: 257-258). He felt also that students working together at a task demonstrated science teaching.

Two participants believed that self-teaching occurred only in certain circumstances. George felt that baking was not self-teaching, stating “it could be a skill that could be applied to a science class” (GCI: 244). “Sometimes the best way to learn something is to actually teach it” (GCI: 58-59) George commented about students problem solving. Cristina claimed that baking could only be self-teaching if it was the first time they had attempted it and believed that there
should be someone to show them what to do. She additionally felt students working together to be self-teaching “if one of them did not understand…and the other person was explaining somehow then that would be science teaching” (CCI: 101, 103-104).

Alex was not convinced of the quality of self-teaching. He saw students working on problems by themselves as “kind of self-teaching themselves” but continued “I’m kind of borderline on this. I really do not consider this total teaching” (ACI: 88-90).

Conceptions of Science

Beliefs about what science is made up of, how it is used, and the nature of science comprise participant’s conceptions of science. All six participants were interviewed, data were analyzed for each participant and categories created to organize their responses. Looking across the “cases” two larger categories emerged: general conception of science and Nature of Science. A definition of each category is presented in the corresponding subsection below and summaries are listed in Table 5-3.

General conception of science

Overarching statements of how participants viewed what science is made up of and how it is used comprise their general conceptions of science. All six participants seemed to have an understanding of science as a body of knowledge. Patrick and Cristina both saw science as a body of knowledge driven by a question. Patrick’s conception of science is that “[science] puts something in front of you and asks a question” (PCI: 76-77). He feels that in teaching science the teacher is “posing a question” and students may not be “thinking the same question but you’re posing a question and hopefully they will answer it” (PCI: 211-214). Cristina also talked of the teacher posing questions and asked “what can I hypothesis hypothesize from this?” (CCI: 40). This she termed the “beginning parts of teaching” (CCI: 211).
Table 5-3. Participant’s conceptions of science.

<table>
<thead>
<tr>
<th>General Conception of science</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Christina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Science</td>
<td>Science as a body of knowledge that’s driven by a question</td>
<td>Science as a body of knowledge used to explain phenomena</td>
<td>Science as a body of knowledge and learned “hands-on” skills</td>
<td>Science as a body of knowledge that’s driven by a question</td>
<td>Science as a body of knowledge whose outcomes impact society</td>
<td>Science as a body of knowledge used to explain phenomena</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alex</td>
<td>Science is human-generated and examined the “impact of what’s going on”</td>
<td>Science is human-generated and proved “things in science change”</td>
<td>Science is fact based on empirical evidence and proved formulai-cally</td>
<td>Science is human-generated &amp; tentative “no such thing as a right answer”</td>
<td>Science is empirical and generated using accepted research approaches</td>
<td>Not mentioned</td>
</tr>
</tbody>
</table>

Alex believed that science was a body of knowledge and skills that could be understood best by learning science concepts and then “hands-on” using scientific equipment. He felt when wanting to show his students the genetics of fruit flies that he would “teach it out of the book first and … have them ready to do it hands-on” (ACI: 156-158) he stated during an interview. He further explained, “you have to use the [Punnett] square first in a simple [way] saying you know you’re mother’s a blonde, you’re father’s got brown hair and you know this is the probability and why you have this color hair. And then going to the fruit flies from there” (ACI: 159-161).

Meredith and George saw science as a body of knowledge used to explain phenomenon. When talking of an inquiry activity on rocks, George felt that the activity of asking students to examine the rocks and “kind of getting the kids to go beyond just what they normally see” (GCI: 22-23). He continued, “so they're looking at more of the texture or hopefully looking at more than just the initial thing so they’re starting to think about rocks as more than just you know what they normally thought of it as” (GCI: 24-26). Meredith’s beliefs of how science explained phenomena were seen in her understanding of biology and other sciences: “it kind of let’s you know what you’re made of and how stuff happens” (MI1: 308).
Isobel believed science a body of knowledge whose outcomes impact society and taught her environmental science class to examine different outlooks on this. She looked for articles about medicine which had different viewpoints. “I wanted one ‘Oh, medicines are [bad]’ a couple ‘medicine is great’ because that’s what we think [but] we really, really need to rethink these medical advances…. How maybe they're not being handled right, to kind of a more of a negative spin or a different look at it” (II3: 212-215). In another class they examined “different ideas” on medical technology research (II3: 218).

**Nature of science**

NOS as agreed upon by researchers is comprised of the understanding that “science knowledge is tentative and generated through empirical work; that all observations are theory-laden and human-generated; that claims involve inferences; and that there are imaginative and creative elements in doing science” (Trumball, Scarano & Bonney, 2006).

Patrick, Meredith, and Cristina focused on the human-generated aspect of science. Patrick discussed the “ecological impact of what’s going on” when discussing a film he used in teaching (PCI: 127-128). Meredith talked of educating her students in evolution helping them “distinguish that this is the science part and it is not to be confused with the belief system but it also helps them potentially become more open-minded towards other things” (MI1: 74-75). Cristina talked about getting her students to “start to think about the difference between what we perceive and [what is] common in society and science” CCI: 171-172). Meredith additionally contended that science was tentative when she talked of helping her students “to see that things in science change” (MI1:76).

Isobel had the understanding that science was empirical explaining that her students should be, “following methodology to a T and if you do not what the repercussions are going to be” (ICI: 182-183). She explained how she wanted her students to work through the problem, “well
my hypothesis failed. Did not come out so what are my errors and can I go back and replicate it” (ICI: 192-194). Cristina also saw scientific knowledge as empirical. When discussing a genetics activity using corn she talked about her students wanting to know what the correct answer of the activity was. She told them “it doesn’t matter if you have the right answer. There is no right answer. It is what you are finding” (CI3:15-16) explaining how science is about evidence, what is observed and experienced.

Alex saw science as fact based on empirical evidence and proved using a formulaic process “just like in a lab. You have to follow steps in a lab or steps to find the [answer]. The scientific method is like following a recipe” (ACI: 240-241).

Conceptions of Learning

Beliefs about learning include the definition or what learning is, whether a teacher is needed for students to learn, and learning from media. To find out the beginning science teacher’s conceptions of learning, I interviewed all six participants. Data were analyzed for each participant and categories created to organize their responses. Looking across the “cases,” three larger categories emerged: Teacher Present for Learning, Learning from media, and definition of learning. Categories are summarized in Table 5-4 and a definition for each category is presented in the corresponding subsection below.

Teacher needed for learning

Whether a teacher needs to be present for learning to occur is discussed by the participants. Two participants felt that there must be a teacher present for learning to occur and questioned whether students could learn alone or from other students. Alex felt that “you would have to teach a lot more” for students to be able to do something from memory (ACI: 209) and questioned whether students would even do an assignment unless the teacher was present.
Cristina felt that a teacher needed to be present to determine if learning could occur and felt students needed someone to direct them when following a recipe the first time (CCI: 229-230).

Table 5-4. Participant’s conceptions of learning.

<table>
<thead>
<tr>
<th></th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Christina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Needed for Learning</td>
<td>Do not need teacher present for learning</td>
<td>Do not need teacher present for learning</td>
<td>Must have teacher present for learning</td>
<td>Must have teacher present for learning</td>
<td>Do not need teacher present for learning</td>
<td>Do not need teacher present for learning</td>
</tr>
<tr>
<td>Learning from Media &amp; Self-teach</td>
<td>Can learn from media and self-teaching</td>
<td>Can learn from media and self-teaching</td>
<td>Need teacher to learn from media</td>
<td>Need teacher to learn from media</td>
<td>Can learn from media and self-teaching</td>
<td>Can learn from media and self-teaching</td>
</tr>
<tr>
<td>View of Learning</td>
<td>Learning should be active “because they’re doing calculations”</td>
<td>Make conscious decision to learn; learn from every experience</td>
<td>Learning is visual and kinesthetic “I like the hands-on”</td>
<td>Learning should be “active”</td>
<td>Learning is visual and kinesthetic; conscious decision to learn</td>
<td>Learning is deep understanding, social; learn from everything</td>
</tr>
</tbody>
</table>

Four participants believed learning could occur without a teacher. Patrick explained; “they’re learning. They have to mix chemicals together, compounds together and they’re reading, following directions (PCI: 257-258). Self-teaching was a “learning experience” to Meredith (MCI: 195). Isobel also felt that one student making something or working together with other students was learning (ICI: 182-184). “Sometimes the best way to learn something is to actually teach it (GCI: 58-59) George noted when discussing students working together.

**Learning from media**

Learning from media is defined as whether students can obtain knowledge from media without a teacher present. Four participants felt that there could be learning from media. Patrick felt that his students could “get information from it” (PCI: 131-132). Choosing to watch media meant to Meredith there was interest in the topic and students would be receptive to the information (MCI: 49-51). Isobel like Meredith saw learning as a conscious decision: “They’re
actually watching something that they could get something from and ask questions about later” (ICI: 43-44). “It is good to learn from different sorts of environments and different mediums” (GCI: 34) George acknowledged.

Two participants were not convinced that any learning could take place from media. Cristina believed that she needed to be in the room while students were watching to get their reactions to see if they were learning (CCI: 84-87). Alex felt that there are too many distractions when watching media at home (ACI: 67-69).

**View of learning**

What learning looks like is how participants view learning. Patrick and Alex envisioned learning as visual and kinesthetic. Alex stated “you have something in front of the students that they can actually look at and put their hands on” (ACI: 33-34). Patrick felt students “might not be able to visualize it without some other aid” (PCI: 187). Christina termed learning as active always wanting to know how “active the students is” (CCI: 72) to determine whether learning had occurred. Isobel, on the other hand, saw learning as doing and observing elucidating “when you're doing it on your own … you’re learning it” (ICI: 201,202).

Both Meredith and Isobel believed there had to be self-motivation or a conscious decision to learn. Isobel discussed a student watching an educational program, “you’ve got a student at home who is watching a TV program on chemical plants. That's a conscious decision.” (ICI: 40-41). Meredith concurred: “unless the child is tied down and forced to watch this that shows that there's some interest in this topic” (MCI: 48-49).

Meredith and George embraced the whole gamut of learning from the media, by experience, by teaching self or others. Meredith talked of learning from every experience. George also expressed a belief that learning was deep understanding and was social averring
“some of them [students] may get some things better than other things and then the person they’re working with may get those things that they do not get” (GCI: 63-64).

**Learner Characteristics**

Learner characteristics are beliefs about learners including their level of prior knowledge, motivation, ability, age and cognitive level. The six beginning teachers were interviewed, data were analyzed and categories created to organize their responses. Three categories of learner characteristics emerged across the individual cases: prior learning, motivation and age and cognitive level. A definition of each category is presented in the corresponding subsection and the summary of the participant’s beliefs of learner characteristics are listed on Table 5-5.

<table>
<thead>
<tr>
<th>Table 5-5. Participant’s statements of learner characteristics.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prior knowledge</strong></td>
</tr>
<tr>
<td>Patrick: Learners come to science with little prior knowledge</td>
</tr>
<tr>
<td>Meredith: Learners have prior knowledge, misconceptions and preconceptions</td>
</tr>
<tr>
<td>Alex: Learners come to science with some prior knowledge</td>
</tr>
<tr>
<td>Christina: Learners have prior knowledge and misconceptions</td>
</tr>
<tr>
<td>Isobel: Learners have little prior knowledge and misconceptions</td>
</tr>
<tr>
<td>George: Learners have little prior knowledge and misconceptions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Motivation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Patrick: Students interested and do work – “overall they try”</td>
</tr>
<tr>
<td>Meredith: Student interest shown by choosing to do tasks</td>
</tr>
<tr>
<td>Alex: Students lack motivation and not trust-worthy</td>
</tr>
<tr>
<td>Christina: Student interest shown by physical response to tasks</td>
</tr>
<tr>
<td>Isobel: Student interest shown by choosing to do tasks</td>
</tr>
<tr>
<td>George: Students have low motivation, a “lackadaisical attitude”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Age and cognitive level</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Patrick: Specific learning activities tied to age/cognitive level</td>
</tr>
<tr>
<td>Meredith: Learning activities tailored &amp; tied to age/cognitive level</td>
</tr>
<tr>
<td>Alex: Specific learning activities tied to age/cognitive level</td>
</tr>
<tr>
<td>Christina: Specific learning activities tied to age/cognitive level</td>
</tr>
<tr>
<td>Isobel: Learning activities tailored &amp; appropriate for age/cognitive level</td>
</tr>
<tr>
<td>George: Learning activities tailored &amp; tied to age/cognitive level</td>
</tr>
</tbody>
</table>

**Prior knowledge**

What a learner knows about science prior to walking into a class is termed the learner’s prior knowledge. All participants expressed beliefs about learner’s prior knowledge of science. Patrick felt his students needed prepping to prepare them for the topic as when he stated “they
have to have done questions in the book by then just to get themselves orientated” (PCI: 194-195). George also felt his students had little prior knowledge claiming “kids typically do not have much of a grasp on weather or anything at this point” (GCI: 106-107). Isobel felt surprised at student’s lack of prior knowledge commenting “they did not know when they flushed the toilet what happened” (II1: 451).

Three participants talked about student’s having prior knowledge. Meredith spoke of student’s “preconceived ideas” being a good starting point for learning to occur (MCI: 192). Alex believed students came to class with prior knowledge and felt he first needed to “know what knowledge level the kids already have” in order to teach (ACI: 25-26). Cristina realized that her students had some prior knowledge because they told her. She reflects, “Once I started talking about the material they will say ‘Oh I remember that from last year’ and I knew that they knew what it was” (CI2: 229-230).

George, Meredith, Cristina, and Isobel all discussed misconceptions students held about science. Meredith shared how she felt a teacher could use a student’s mistaken statement about the difference of color in arterial and venous blood, “well it gives the teacher a really good opportunity to answer this question, correct misconceptions of there are any” (MCI:189-191). Cristina understood that students have misconceptions and tried to inform her students that “there [are] misconceptions in the world and what science really teaches us” (CCI: 173-174). Isobel also felt that when students had misconceptions about certain concepts, “they do not know when those things happen… it is a prime opportunity” to direct their investigations (ICI: 164-168). George talked in depth about student misconceptions on the geologic time cycle and how he would work to change those conceptions (GCI: 208-224).
Motivation

A learner’s motivation is defined as their interest in and engagement with science. Four participants questioned their student’s motivation. Alex had a negative view of his student’s motivation and believed they would damage or destroy materials when passed around (ACI 34-35). George saw a “sort of a lackadaisical attitude” (GI: 263-264) and felt his 7th grade students did not take learning science seriously enough. Patrick stated “overall they try” speaking of his students but talked of “hovering around the room making sure everybody kind of stayed on task” (PI2: 73-74). Christina tied motivation to physical response “if the student is sitting there and actually responding to what’s going on” (CCI: 82-83) she felt they were motivated. She called it active learning.

Meredith and Isobel saw motivation as student interest and choosing to do something. Meredith talked about students watching a science documentary: “that shows that there's some interest in this topic anyway because they’ve chosen to watch this they will probably be more receptive to the information there” (MCI: 49-51). Isobel called it a “conscious decision” and continued. “They’re actually watching something that they could get something from and ask questions about” (ICI: 41, 43-44).

Age and cognitive level

Age and cognitive level were viewed as the beliefs participant’s possessed about whether learners were of an appropriate age or cognitive level to understand the science being taught them. All respondents had beliefs about student age and cognitive level. Patrick, Alex and Cristina felt that different types of learning activities might be difficult for different age level students. Patrick commented, “I think middle school, that age bracket may be a little more of a leap to get them [understanding the material] (PCI: 49-50) when talking about using boxes of butterflies for inquiry learning. “I’m not sure that’s the right level” Alex responded when asked
if there was learning going on when a professor lectured first graders (ACI: 113). He also stated “ninth grade I’m not sure is ready for fruit flies” (ACI: 140). When talking of a genetics project. Cristina commented about inquiry “I think for my students anyways it is just something that they could not handle so I don’t use that when I am teaching” (CCI: 61-62).

Meredith and Isobel, and George all believed that learning activities needed to be tailored to age and cognitive level. “I think the material though is completely appropriate for that class” (MCI: 132-133) Meredith averred when discussing Punnett squares being introduced to 9th grade students. Both Meredith and George linked concept understanding to both age and cognitive level. “[They should] do something like looking at fish and saying what happens when predators come to eat the fish and then that they can visually see [it] happening. They might grasp the concept” (MCI: 107-110) Meredith felt when discussing how to teach first graders about natural selection. When asked about lecturing on Darwin’s theory George commented, “this particular example would … probably be on the level of most middle school kids GCI: 89-91). Isobel conceptualized that materials and topic needed to be appropriate to the student’s age and cognitive level (ICI: 77-78).

**Conditions for Instruction**

Hewson and Hewson (1988) based their conditions for instruction on the Hirst-Fenstermacher framework (1971; 1986) having four components for teaching: 1) for teaching to occur, there must be learning, 2) the learning have an outcome, 3) the teacher must support the student, and 4) the goal is to teach a student. Conditions for instruction are beliefs about what is needed for teaching and learning to occur.

All six beginning teachers were interviewed, data were analyzed and categories created to organize their responses. Three categories emerged across the individual cases: conditions for teaching and learning, a quality component, and other factors. A definition for each category is
presented in the corresponding subsection below and a summary of the participant’s conditions for teaching and learning are listed on Table 5-6.

**Conditions for teaching and learning**

Conditions for teaching and learning are beliefs about what is needed for teaching and learning to occur. Two of the respondents felt that teaching required an instructor. Alex questioned: “is it teaching when you have them open a book in the library and have them read on their own?” (ACI: 87-88). Cristina needed in most cases to see student response to determine whether learning was occurring (CCI: 81-84).

Table 5-6. Participant’s conditions for instruction.

<table>
<thead>
<tr>
<th>Conditions for Teaching and Learning</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Christina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Component</td>
<td>Teaching aids to present material &amp; student response</td>
<td>Questions used to stimulate learning</td>
<td>Good teaching to present material/standards</td>
<td>Teacher presents material &amp; evidence of learning</td>
<td>Need student response and follow-up questions</td>
<td>Material presented must be tied to concepts</td>
</tr>
<tr>
<td>Quality of materials used</td>
<td>Quality of materials used</td>
<td>Quality of materials and teaching</td>
<td>Quality of teaching</td>
<td>Quality of questions</td>
<td>Quality of materials used</td>
<td></td>
</tr>
<tr>
<td>Other Factors</td>
<td>None mentioned</td>
<td>Must have goals and purposes for instruction</td>
<td>Have to take into account district values</td>
<td>None mentioned</td>
<td>Must have proof of learning having occurred</td>
<td>Must have goals and purposes for instruction</td>
</tr>
</tbody>
</table>

Patrick required teaching aids for teaching and learning to occur. He stated that “learning [is] going on just depending on what you’re using to present the material” (PCI: 185-186). He felt students might not be able to visualize concepts without teaching aids (PCI: 187-190).

Three respondents felt that questions were needed for teaching and learning. Patrick believed learning was occurring when students asked questions “because you’re asking what’s happening next so you know what’s happened prior (PCI: 209-210). Meredith perceived there
needed to be questions to stimulate student learning (MCI: 205-208). She talked of using a Disney-produced video to focus students on concepts they were studying: “I chose to ask students questions based upon what we were talking about in osmosis and things like that.” (MCI: 60-62). Isobel thought that the quality of student response and follow-up questions posed determined whether teaching and learning occurred (ICI: 12-13).

George conceptualized that material presented needed to be tied to the concepts. He mused “if there’s nothing behind it. If they’re not learning something else to go along with it is not going to be useful for science (GCI: 168-170). George liked to tell stories when presenting material but always made them relevant to the topic. When speaking of geothermal power he told the story of him burning himself on hot water in a shower in Iceland where they use this power source (GCI: 37-38).

**Quality component**

The quality of materials and equipment, and quality of the teacher are defined as the quality component. All respondents discussed quality when talking of conditions of teaching and learning. Quality of materials was important to Patrick, Meredith, Alex and George. Patrick illustrated his concern in his statement about students watching a video at home, “[they’re] probably going to get a lot of information from it. It is just I do not [know] what type of information they are getting from it.” (PCI: 131-133). Meredith looked at the quality of media watched by her students: “probably is some type of documentary or educational programming. It is probably not some cartoon” (MCI: 51-52) she posited. Making materials and borrowing from other teachers fueled Alex’s concern over the quality of materials (AI2: 379-380). George was pleased with the amount and quality of media for student use during and after Hurricane Katrina which made hurricanes a great instructional unit (GCI: 97-101).
Alex, Cristina and Isobel were anxious about the quality of teaching and the teacher in teaching and learning. For Alex quality teaching was what he called “total teaching” (ACI: 89-90). Cristina felt that learning could occur only if it was the first time a student learned the material and with a quality called “real learning” when she discussed students using a self-study aid (CCI: 255-256). Isobel focused on quality of teacher response and student participation (ICI: 12-13).

Other factors

Other factors are defined by participants as values of the district that need to be adhered to, proof that teaching and learning occur and goals of instruction. Alex felt that values of his district had to be closely adhered to and stated, “Our school board tells us we have to teach intelligent design along with Darwin’s theory. We had a meeting after class on that because they’re trying to cover all their bases so nobody gets upset about what’s taught.” (ACI: 117-120). Isobel looked for proof that learning had occurred as when she felt that students who were cooking at home should bring samples of their project in for her. Meredith questioned the goals and purposes behind a particular type of instruction (MCI: 232). George also searching for the goal of instruction asked “What is the intent of this?” (GCI: 284).

Instructional Strategies

Instructional strategies are teacher’s beliefs about the techniques needed for successful teaching including textbook strategies, kinesthetic activities, and presentation. This is one of the two observable components of Hewson and Hewson’s (1988) Conceptions for Teaching Science. Six participants were observed and interviewed, data were analyzed and categories chosen to organize their responses. Five categories emerged across the individual cases: favored instructional strategies, types of questions, kinesthetic activities, textbook strategies, and ways of
presenting material. A definition for each category is presented in the corresponding subsection and a summary of the participant’s conditions for teaching and learning are listed on Table 5-7.

Table 5-7. Participant’s instructional strategies.

<table>
<thead>
<tr>
<th>Favored Teaching Strategies</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Christina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture, projects, activities, examples</td>
<td>Activities, projects, internet, examples</td>
<td>Lecture, KWL, demos, activities</td>
<td>Lecture, activities, examples</td>
<td>Discuss, demos, examples, problems</td>
<td>Story-telling, demos, projects</td>
<td></td>
</tr>
<tr>
<td>Focused questions and teacher-led discussion</td>
<td>Open-ended and inquiry questions</td>
<td>Focused questions and teacher-led discussion</td>
<td>Focused questions and teacher-led discussion</td>
<td>Open-ended and inquiry questions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissect, draw, label, and create</td>
<td>Models and memory aids</td>
<td>Hands-on activities and projects</td>
<td>Learning aids and experiments</td>
<td>Experiments and activities</td>
<td>Projects and activities</td>
<td></td>
</tr>
<tr>
<td>Use textbook as guide and reference</td>
<td>Use textbook as reference</td>
<td>Use textbook to teach and in activities</td>
<td>Use textbook as reference, activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual aids and Power Point to present</td>
<td>Visual aids and internet to present</td>
<td>Visual aids for demo and to present</td>
<td>Story-telling and visual aids to present</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Favored strategies**

The instructional techniques used most by participants were defined as their favored strategies. Strategies that were used most often ranged from lecture (Patrick, Alex and Cristina) to examples to projects to storytelling to the simple KWL put forward by Alex. KWL is a three step process to learning which begins with what the student Knows of the subject, continues with what they Want to know about the subject, and concludes with what is Learned after the subject is taught. Projects were used by Patrick, Meredith and George and all participants used activities
and demos. George used storytelling as a favorite strategy and three participants (Patrick, Meredith, and Isobel) used examples to teach.

**Types of questions**

Types of questions as a category is defined as those questions participants used in teaching science. All participants felt that questioning and discussion were important strategies but Patrick, Cristina, Alex, and Isobel felt they should be focused questions and teacher-led discussion. Isobel felt that inquiry questions should be more focused maintaining she would ask her students “what can you tell me about the type of crystal, if there was a question about maybe structure or where would you find them?” (ICI: 27-29). Meredith and George used open-ended questions and inquiry.

**Kinesthetic activities**

Kinesthetic activities are those activities where students have to move around such as in laboratory experiments, projects, and activities. All participants used some sort of kinesthetic activities for the student which Alex called hands-on and projects, Cristina termed active, George labeled experimenting and Meredith dubbed as activities. Although Patrick never mentioned activities he was very activity-focused in class having students dissect, draw, label, and create science items. All participants used demonstration and examples.

**Textbook strategy**

Textbook strategy is defined as using the textbook as part of an activity in class such as reading aloud or in seatwork. Using the book was a teaching strategy supported by Patrick, Alex, and Isobel. Patrick used the book as a guide for the information he was teaching and had crosswords, activities, and worksheets designed to focus on students learning information from the book. Alex followed the book in sequence from front to back and used activities and demos it suggested as he taught concepts directly from it. Isobel also used problems and examples from
the book when teaching her unit on gases but brought in demos and labs which illustrated concepts in the chapters.

Meredith, George and Cristina referred to the book, using it as a reference. Meredith used the book as a guide to instruction, changing it as needed and using a new version of the book and web sites for activities. George followed the book loosely using the web for supplementary information and review questions from it as a jumping off point for discussion. Cristina used the book exclusively to plan and followed the book, using textbook questions for review.

Presentation

Presentation is defined as the medium that the teacher uses to deliver information to the class. All teachers used visual aids to present material. Patrick and Cristina developed slides using PowerPoint to teach each lesson while Meredith used internet science sites. George also talked of using PowerPoint and the internet but his ICD projector had been broken for a month. Alex constructed his own visual aids to demonstrate different science concepts. While Isobel and George preferred storytelling, Patrick was very forceful about the necessity of visual aids to teaching and learning, stating “there’s definitely learning going on just depending on what you’re using to, to present the material” (PCI: 185-186).

Comparisons between Components of Orientations to Teaching Science

Background

Orientations toward teaching science are a component of pedagogical content knowledge first named by Grossman (1990) and seen as the overarching component of PCK which shaped all others (Figure 5-2). “An orientation” says Magnusson, Krajcik and Borko (1999) “represents a general way of viewing or conceptualizing science teaching” and “serves as a ‘conceptual map’ that guides instructional decisions” (p. 97). My six teacher’s orientations were driven by their
goals and beliefs about teaching, and restricted by the context of their schools, districts, and student populations. Mentors played a huge role in orientation for all of my participants, many of them teaching as their mentors taught.

**Goals for Teaching**

Specific objectives a teacher has for their students’ education; can be science, general, and affective goals are the goals for teaching. Six participants were observed and interviewed, data analyzed and categories created to organize their responses. Three categories emerged across the

<table>
<thead>
<tr>
<th>Goals for Teaching</th>
<th>Science Curriculum</th>
<th>School Context</th>
<th>Learner Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific objectives a teacher has for their students’ education; can be science, general, and affective goals</td>
<td>Science subject matter needed to be taught to students as mandated by federal, state, and local standards</td>
<td>Constraints placed on teaching due to type of school, teaching assignment, teacher issues, and other factors</td>
<td>Beliefs about learners including their prior knowledge, motivation, ability, age and cognitive level</td>
</tr>
</tbody>
</table>

![Diagram](image)

Figure 5-2. Categories for Orientations to Teaching Science (Modified from Magnusson, Krajcik & Borko, 1999).
individual cases: science goals, general goals and affective goals. Categories are defined in corresponding subsections below and a summary of the participant’s goals for teaching are listed on Table 5-8.

Table 5-8. Participant’s goals for teaching.

<table>
<thead>
<tr>
<th></th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Christina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Goals</td>
<td>Students understand science content; gain science skills; explore career in science</td>
<td>Students understand science content</td>
<td>Students understand science content; gain science skills; career in science; science as real-world</td>
<td>Students understand science content; see science as real-world</td>
<td>Students understand science content and gain science skills</td>
<td>Students understand science content; see science as real-world</td>
</tr>
<tr>
<td>General Goals</td>
<td>Students need academic preparation</td>
<td>Students develop life skills; attain academic success</td>
<td>Students need to develop life skills</td>
<td>Students need to develop life skills</td>
<td>Students need to develop life skills</td>
<td>Students develop life skills; attain academic success</td>
</tr>
<tr>
<td>Affective Goals</td>
<td>None mentioned</td>
<td>Develop excitement for science</td>
<td>Develop interest in science</td>
<td>Develop excitement for science</td>
<td>Develop excitement for science</td>
<td>Develop excitement for science</td>
</tr>
</tbody>
</table>

Science goals

Science goals are specific objectives teacher has for student learning in science. All beginning secondary science teachers shared the goal of student’s understanding science content. Alex called it getting a good science base (AI1: 243) where Patrick expressed the desire “just for [students] to try to learn the material, do well” (PI2: 49). George claimed, “I’m just trying to get them prepared as best I can for the science which is next” (GI1:390-391). Science literacy was the goal of both Meredith and Isobel. Isobel expressed her goal for students: “if they have a basic understanding … if they can take up a newspaper and read about medical advances and they can take an opinion poll … then I’ve done what I’m supposed to do” (II3: 202-206). Cristina had two
different elements of her goal of science literacy for her students; them being able to visualize concepts and to engage them in the content (CI4: 74, 87-88).

Three participants wanted their students to gain science skill. Patrick’s goal for students was to learn dissection: “I would love for them to be able to dissect a muscle like cow muscles or something like that” (PI2: 250-251). “The basic goal was for them to at least use a microscope … get them some hands-on with a microscope and with slides, cover slips, things of that sort” (AI3: 111,113) Alex stated. Isobel wanted students to “do more labs, to get familiar with the different types of equipment” (II2: 148).

Three participants shared they wanted students to be interested in a career in science. “Part of our job assignment was to pick a field, learn about it … that actually opened the eyes of a lot of kids” (PI1: 370, 374) Patrick shared. Meredith commented, “I really would love for them to suddenly develop an interest in or a love for science like I have … my teachers that did that for me (MI1: 232-233). “I try to encourage them all to go further in science” (AI1: 206) Alex remarked.

Alex, Cristina and George really wanted for their students to see how science relates to the real world. “So I just try to take the text and relate it to something that they can relate to” Alex shared (AI1: 256-257). Cristina discussed a genetic activity comparing eye color: “the eyes definitely relate it to them so that would be the one main part” (CI3: 44-45) when speaking of her goal. George’s goal was to “hopefully get something from their lives that I can maybe relate back to whatever we’re doing” (GI2: 6-7).

**General goals**

Specific objectives teacher has for a student not focused around science learning are termed general goals. Four participants wanted to help their students develop life skills. George stated, “in both the classes I try and give them life skills (GI1: 279). Alex felt that learning,
thinking, and functioning in society was an important life skill (AI2: 793; AI3: 94-97). Problem solving was a life skill stressed by Meredith and Isobel. Looking at “different ways like to how you can logically decide if an answer is good or wrong; correct or [in]correct” (MC2: 10-11) was how Meredith saw it.

Academic success was a goal for three participants. Alex wanted his student’s to try to attain the highest grade they could. He told them to “shoot for that A” and feel good about what grade they get “as long as you’ve done your best” (AI2: 453-454). “I try to stress it, you know to me mediocrity is not ok” Alex affirmed. George wanted students to “put their best effort into it.” Their students passing the high-stakes test was an additional academic success goal for Alex, Meredith, and Isobel.

Two participants had goals of academic preparation. A primary goal for Cristina was to have her students write a research paper on a topic of their choice utilizing research databases (CI1: 274-276). Patrick’s academic goal for his students was knowledge of research and technology. “Just to get them using audiovisual stuff, technology stuff … and be able to pull stuff from reference books” (PI3: 7-8).

**Affective goals**

Excitement for science was a goal for four participants. Meredith stated, “I would really love for them to suddenly develop an interest or a love for science like I have” (MI1: 232). Cristina, Isobel and George wanted to get students excited about the subject. “I just want to get them excited about the material” (CI1: 367) Cristina acknowledged. Isobel concurred wanting her students “Seeing things in the lab, actually getting excited about things” (II2: 164-165). George worked with his students “to try and keep their interest but still give them as much facts and things as I can to so they will be prepared (GI1: 274-275). Alex wanted students to develop an interest in science.
Science Curriculum

Science subject matter needed to be taught to students as mandated by federal, state, and local standards is defined as science curriculum. Observation and interview data were analyzed for the six participants and categories created to organize their responses. Two categories emerged across the individual cases: purpose of curriculum, and how the textbook is used. A definition for each category is presented in the corresponding subsection below and a summary of the participant’s focus on science curriculum are listed on Table 5-9.

Table 5-9. Participant’s focus on science curriculum.

<table>
<thead>
<tr>
<th>Purpose of Curriculum</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Christina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum important for academic preparation</td>
<td>Curriculum important &amp; aligned with standards</td>
<td>Curriculum important; aligned with standards and textbook</td>
<td>Curriculum important and seen as textbook</td>
<td>Curriculum important; aligned with standards</td>
<td>Curriculum important; aligned with previous year</td>
<td></td>
</tr>
</tbody>
</table>

| Textbook | Text broken into small sections to teach; too watered down | Textbook used as reference; new one better | Jumps around in text when teaching | Text taught in small sections; jumps around in text | Textbook used as reference; too hard for students | Textbook used as reference in teaching |

Purpose of curriculum

The overarching goal for teaching the curriculum was the purpose of curriculum. This was important for all participants. Patrick had his curriculum laid out according to what he called “orientations” and systems of the body (PI2: 309-311; PI3: 218). Meredith had her curriculum ordered but had thoughts of rearranging it next year (MI2: 269-272). Alex followed the order in the book (AI4: 115-118) as did Cristina who stated “I want to cover all of the areas in the book (CI1: 284-285). “I have a textbook to use and I kind of pick and choose amongst that and what they say they need to know and then what I think that they need to know” (III: 603-605) Isobel
explained. George used the curriculum from “the previous teachers … looking at what they’ve done” (GI1: 459, 460) and added what he thought was important.

Curriculum alignment was important for four participants. Meredith stated “there are science or state standards correlated to these things” when speaking of a unit she was teaching (MI1: 303-304). When writing lesson plans Alex commented “the state wants to know which standard” (AI2: 562) tied to the concept he was teaching. “We tie [curriculum] into Sunshine State Standards” (II4: 230) Isobel declared. George, teaching in a private school, aligned his curriculum with past teachers in the same subject: “basically the curriculum that they used last year … so I took the parts that were emphasized to me that they wanted me to cover” (GI2: 258, 260).

Textbook

Textbook as a category was defined as what role the textbook played in the curriculum. All teachers felt that the text was a large part of their curriculum. Two participants taught with their textbook. Cristina felt that she could not teach without the textbook but found that she had to break the information up into smaller sections to present it to her students. Alex also taught from his text but had to jump around to teach all of the information he felt students should know.

Four participants were unhappy with their textbooks and used them as a reference when teaching. Patrick felt his text was too watered down and wanted one with more “rigor” (PI1: 484-486). Both Meredith and Isobel were on the textbook committee and were looking forward to new texts for next year since Isobel felt her text was too difficult and more on a college level (II1: 634). Meredith preferred teaching from the new text and supplements she had been given (MI2: 208-209). George felt that some things in the text were above his student’s ability level especially the math problems (GI1: 462-464)
School Context

School context is defined as constraints placed on teaching due to type of school, teacher assignment, teacher issues, and other factors. Six participants were interviewed and data were analyzed. Three categories emerged across the individual cases: school type, the school’s rating on high-stakes tests, and other factors. A summary of the participant’s school context are listed on Table 5-10.

Table 5-10. Participant’s school context.

<table>
<thead>
<tr>
<th>School Type</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Cristina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural public school</td>
<td>Rural public school</td>
<td>Urban public school</td>
<td>Urban private school</td>
<td>Rural public school</td>
<td>Urban private school</td>
<td>7th grade earth/space science; vertebrate biology</td>
</tr>
<tr>
<td>Teacher assignment</td>
<td>Anatomy and physiology</td>
<td>Biology; 8th grade general science; honors biology</td>
<td>Biology; integrated science</td>
<td>Biology; marine science</td>
<td>Anatomy and physiology environmental science; honors chemistry</td>
<td>Not mentioned</td>
</tr>
<tr>
<td>Teacher Issues</td>
<td>Lack proper facilities for instruction; technology scheduling; not enough budget for materials</td>
<td>Need technology equipment; not enough budget for materials; high-stakes testing</td>
<td>Lack proper equipment and facilities; not enough budget for materials; lack of time to lesson plan; high-stakes testing</td>
<td>Lack of proper equipment including technology; not enough budget for materials; lack of time to lesson plan</td>
<td>Lack proper equipment and facilities needed renovating; lack of time to lesson plan; high-stakes testing</td>
<td>Equipment unusable and materials not organized; technology broken; lack of time to lesson plan</td>
</tr>
<tr>
<td>Other Factors</td>
<td>Principal observes teaching</td>
<td>Principal observes teaching</td>
<td>Submit lesson plans; principal observes teaching</td>
<td>Not mentioned</td>
<td>Submit lesson plans; principal observes teaching</td>
<td>Not mentioned</td>
</tr>
</tbody>
</table>

School type

School type is defined as what type of school is being taught in that is, whether it is rural, or urban, and whether public or private. Four participants taught in public schools, two in County
One, the third in County Two, and the fourth in County Three. Of these four, three teachers taught in rural schools with a population that was largely agricultural, one in each of the three counties mentioned above and one taught in an urban school in County Two. Two participants taught in private urban schools in counties Two and Four.

Teaching assignment

Teacher assignment is defined as the number and type of courses taught and the grade level of students instructed. All participants taught general biology or some advanced level course in biology. Meredith teaches three biology and one honors biology class. Alex teaches one biology class also. Cristina teaches four biology and one marine science class. George teaches a vertebrate biology class. Patrick and Isobel teach anatomy and physiology. Isobel also teaches an environmental science class.

Four participants also teach other science classes. Meredith teaches 8th grade general science. Alex teaches four integrated science classes. Isobel teaches an honors chemistry class. George teaches classes in 7th grade earth/space science. Two participants teach science to both middle and high school students, necessitating a change in both teaching techniques and classroom management strategies between the different grade levels.

Teacher issues

Teacher issues are the issues teachers feel have an impact on their teaching. Five beginning teachers had some issues with the equipment they were provided to teach with. Alex was only provided two microscopes for his class of twelve biology students, both of which worked poorly. Additionally he had only a classroom set of textbooks and could not assign homework for his students. Isobel’s lab room was missing Bunsen burners and she had to order them. George had a full supply closet but was unable to find anything on its overstocked shelves. Cristina commented that she purchased a lab aid out of her own money so that she could better explain biology concepts.
Patrick, Alex and Isobel had issues with the facilities in their classrooms. Patrick had a rug on his floor that made it difficult to perform science experiments and desks for his students instead of tables and benches. Alex was teaching in a modular classroom with no water, no storage, and no laboratory. Isobel had to have her gas and electric lines repaired so that she could perform experiments in her classroom.

Four teachers, Patrick, Meredith, Cristina, and George, had issues with their technology. Patrick had problems with technology availability having problems getting equipment ordered from the media center at the times he needed it. Meredith had no pointing device to use with her computer to enable her to walk around the room as she was showing her PowerPoint slides and web sites. This caused her to be tied to her computer which was also a problem for Cristina. George had grown dependent on his LCD projector as part of his teaching strategies but it was broken and had been gone over a month.

Four participants also had problems with materials. Patrick had a small budget which made it hard for him to order dissection supplies. Isobel, Alex and Meredith also had little money for materials and shared with me that they financially could not supply the missing materials from their own pocket. Patrick and Meredith added that they modified activities to use the materials they had. “[I] found something where they would use macaroni but I did not have macaroni. So I sort of improvised based upon the resources that we found here and we had paper” (MI3:105-107) Meredith explained about a meiosis-mitosis activity she had modified.

Three participants felt that lesson planning took too much time. “I spend six, seven hours doing that. Preparing the transparencies and reading everything that needs to be read” (AI2:221-223) Alex shared when speaking of lesson planning. George stated that at times he was unable to plan and just skimmed over the material to familiarize him with the lesson. Cristina discussed the
difficulty of putting in extra hours on planning due to a second job she was working. She declared “I'm just barely keeping my head above the water trying to get everything done” (CI1:121-122).

Three of the teacher participants taught core courses in public schools with high-stakes tests. These tests lasted a week and these teachers were responsible for monitoring tests and tutoring students prior to them. Two rural schools, in counties One and Three, where Meredith and Isobel teach as well as the urban school in County Two where Alex teaches are struggling schools, not having scored high on the high-stakes tests.

Other factors

Other factors are issues which may place constraints on what and how a teacher teaches science. Administrators in the two schools where Alex and Isobel teach require all teachers to submit formal lesson plans. This is district policy for public schools in both counties Two and Three. Four participants who are public school teachers (Patrick, Meredith, Alex, and Isobel) have classroom visits by the principal on a regular basis. This is also district policy for all public schools.

Learner Characteristics

Learner characteristics are participant’s beliefs about learners including their prior knowledge, motivation, ability, age and cognitive level. Six participants were interviewed and data were analyzed. Three categories emerged across the individual cases: students’ cognitive ability and developmental level, motivation, and understanding of content. A summary of the participant’s school context are listed on is shown on Table 5-11.

Cognitive ability and developmental level

A student’s capacity for learning and their maturity is defined as their cognitive ability and developmental level. All of the six beginning secondary science teachers talked of student ability
and defined it as intelligence. Alex was very grade-focused in seeing student ability. He defined ability as “from the lower standard to the higher standard education-wise” (A12: 100-102) and talked about the grade students were earning when speaking of them. Cristina defined ability as ‘getting it’ said “there are some of them that just do not get it and you have to really, really work with them and there are some that are higher” (C12: 103-104).

Table 5-11. Participant’s view of learner characteristics.

<table>
<thead>
<tr>
<th>Cognitive Ability and Developmental Level</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Christina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ranges cognitive ability</td>
<td>All ranges cognitive ability</td>
<td>All ranges cognitive ability</td>
<td>All ranges cognitive ability including special needs</td>
<td>All ranges cognitive ability &amp; develop. level including special needs</td>
<td>All ranges cognitive ability &amp; develop. level including special needs</td>
<td>All ranges cognitive ability &amp; develop. level including special needs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Student’s have positive interest and motivation; some will not do their homework</th>
<th>Students ambivalent towards work; cheating; need hands-on</th>
<th>Students not alert or actively involved; need labs to stimulate interest</th>
<th>Students not alert or actively involved</th>
<th>Students ambivalent towards work; labs to stimulate interest</th>
<th>Students will not do homework, cheat or copy; talking and rowdy in class; jokes stimulate interest</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Understanding of Content</th>
<th>Students have good understanding</th>
<th>Student understanding varies</th>
<th>Students did poorly on test; need to break down content</th>
<th>Students did poorly on test; need to break down content</th>
<th>Students able to “pull things together”</th>
<th>Students have low math &amp; grammar skills; memorize; “connect the dots”</th>
</tr>
</thead>
</table>

Patrick and Isobel saw the majority of their students as bright. Patrick maintained, “They’re all bright kids” (P12: 37-38). Isobel claimed, “I think my students are very able. I think they’re very bright” (I12: 50). George spoke of the diversity of ability of students in one class “at the same time I’ve got some really exceptionally smart kids and I have some kids who are not as smart” (G11: 269-270). Alex, saw students in his biology class as “relatively smart” (A14: 54).
Alex, Cristina, Isobel and George spoke of their special needs students. Alex commented, “I have a couple of my students that are considered learning disability or ESE whatever they want to call them” (AI2: 129-130). Isobel spoke about “one of my female students [who] is ESOL” (II4: 94). Cristina also talked special needs students, of “kids below the 25%” (CI1: 176). George, being in special education as a child, saw many of his students as special needs but felt it was “an age-related thing” (GI2: 115) and that his 7th graders “just middle schoolers and dealing with everything” (GI2: 124).

Both Cristina and George were concerned with their student’s developmental levels. Cristina felt that her students, due to their age, could not take notes and pay attention at the same time (CI2: 47-49). This caused her to provide her students with fill-in-the-blank notes as she felt there was no way to teach the material without the notes (CI1: 261-263). George felt his students had a “problem with their math skills [and] in their ability to write” (CI1: 146-147) and was concerned that he had to spend so much time on this issue.

**Motivation**

Motivation is defined as a student’s interest in and enthusiasm for learning. All participants were concerned with student interest and motivation, seeing students both positively and negatively. Patrick maintained of his students that “they get interested and really that’s a good part” (PI1: 340). Meredith, Isobel and George saw their students as ambivalent towards schoolwork. “Seriously there were five minutes left in the lab and they had not even set up the slides. I was just kind of baffled” Meredith commented on her students’ ambivalence (MI1: 222-223).

Alex and Cristina were concerned with alertness and active involvement in the lesson. Alex stated “with the types of students we have some of them are just here marking time sadly
enough” (AI2: 110-111). Cristina bemoaned “the people who are not actively participating” (CI2: 175).

Four participants spoke of various student motivation problems. Meredith and George dealt with cheating in their classrooms. Meredith commented “they are notorious for copying one another” (MI2: 146). George explained about his students “they do not seem to understand that you know cheating is wrong” (GI1: 305). He also discussed his “rowdier group,” the class whose members talked (GI3:261). Patrick and George commented that their students did not want to do homework. George was additionally concerned with students copying their work from others. “Kids who are getting A’s on tests usually blow off homework assignments” (PI2: 415) Patrick averred. George talked about both issues: “they do not typically do their homework as well. If they do it then chances are half of them were copying” (GI4: 111-113).

Four participants discussed how they stimulate student interest. George used jokes to trigger student interest: “jokes and things that I think kept them more interested” (GI4: 33-34). Both Isobel and Alex used labs to stimulate interest in learning and Alex shared, “anytime I do a lesson that really goes well I try to have some sort of experiment that, that the kids like to do” (AI1:115-116). Meredith felt that hands-on experience would stimulate interest in the subject and “ingrain it into their heads a little better” (MI3: 12).

**Understanding of content**

Student comprehension of science is the understanding of content. Two participants were concerned with their student’s performance on tests. At the beginning of the year both Cristina and Alex had a majority of their class bomb a test and had to learn to break down the material and teach it a different way. George’s big concern was his student’s low math and grammar skills and their focus with memorizing and taking the test rather than comprehending the material. Meredith grew frustrated with her students who were “goofy” (MI2: 99).
Patrick, George and Isobel felt that their students were getting it, able to “pull things together” (II4: 301) as Isobel commented or to “connect the dots” (GI3: 151) as George succinctly phrased it. Patrick put it another way. “They understand it. I know they understand it because of some of the questions I get” (PI3: 164) he observed.

**Rationale for Instruction**

How the teacher chooses to lesson plan and assess learning of science and the reasoning behind both tasks are a teacher’s rationale for instruction. Hewson and Hewson (1988) state that science teacher “should be able to use their knowledge of the particular content to be taught, the particular students they will be teaching, and effective instructional strategies to plan and perform teaching actions which achieve the intention of helping these students learn the desired content” (p. 611). Planning and assessment, and the reasoning behind both of these actions, can be considered the teacher’s rationale for instruction. These will also show a teacher’s orientation to teaching science.

Six participants were interviewed and observed, data were analyzed and categories created to organize their responses. Two categories emerged across the individual cases: lesson planning and assessment. A summary is shown in Table 5-12.

**Lesson planning**

Lesson planning is the breaking down of subject matter into specific concepts and terminology to be taught in a lesson and determining demonstrations, activities, and other instructional strategies to use to teach them. All participants used the textbook in lesson planning to greater or lesser degrees. Three participants used it as a starting point. “I was an anatomy and physiology major,” Patrick stated, “so I just look over my old notes and I kind of water them down then I go back and I look over our textbook and I pull the information out of the textbook that you know coincides with stuff we need to do” (PI3: 190-193). Alex first read and highlighted all important
sections and added information from the teacher’s edition. “I usually start with the book, make my notes” (CI1: 244-245) Cristina shared.

Table 5-12. Participant’s rationale for instruction.

<table>
<thead>
<tr>
<th>Lesson Planning</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Christina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used textbook and college texts for planning; used internet and technology</td>
<td>Used textbook and supplements for planning; used internet &amp; technology</td>
<td>Used textbook and college texts for planning; turned in formal lesson plans</td>
<td>Used textbook and college texts for planning; used technology</td>
<td>Used textbook for planning; used technology; turned in lesson plans</td>
<td>Used textbook and college texts for planning; used internet and technology</td>
<td></td>
</tr>
<tr>
<td>Assessment</td>
<td>Testing a major part of curriculum; was poor test-taker; teaches strategies; concerned with high-stakes tests &amp; student grades</td>
<td>Testing a major part of curriculum; teaches strategies; concerned with student grades</td>
<td>Testing a major part of curriculum; was poor test-taker; concerned with high-stakes tests &amp; student grades</td>
<td>Testing a major part of curriculum; concerned with student grades</td>
<td>Testing a major part of curriculum; teaches strategies; concerned with high-stakes tests &amp; student grades</td>
<td></td>
</tr>
</tbody>
</table>

Isobel and George skimmed the textbook to ensure that he had the concepts down but relied on his knowledge to develop a lesson correctly. Meredith used her new textbook for unique activities and extra material that the current book lacked, stating “that’s been really helpful having access to the upcoming edition to use now so that’s definitely been helpful. So it is like quadrupling my resources” (MI1: 327-328).

All teachers used supplements in their lesson planning. Alex read through the “seven or eight books that support the actual textbook” (AI2: 212-213) to find activities, demos and models which focused on his hands-on orientation. Cristina used college texts (CI2: 246) as did Patrick.

Four participants used the internet and technology. Patrick made PowerPoint slides for information and handouts of the diagrams so students had the diagram in front of them when he
was lecturing (PI3: 74-76). George, at the time I observed him, bemoaned the loss of his LCD projector as he had to draw diagrams and could not use the resources of the internet for his class during the time it was being fixed (GI2: 56-60). Meredith used a web site as the meat of one of her lessons on the similarities and differences between mitosis and meiosis (MO3). Cristina explained her lesson planning strategy: “I might use Internet, college textbooks, online lesson plans. I’m always trying to add extra material.” (CI2: 246-247).

Formal lesson plans were a requirement of the school systems Alex and Isobel were employed by. Alex commented: “Our [school] just requires us to have copies or have them on the computer” (AI2: 534). Isobel had to turn weekly lesson plans in to the principal.

Assessment

Assessment is the formative and summative techniques developed to determine what a student has learned and allows a teacher to know what prior knowledge a student possesses as well as how well they have retained the concepts and terms that have been taught. All of the six participants felt that testing was a major part of assessment and the three male teachers (Patrick, Alex, and George) admitted that they had been poor test-takers.

Because of this each of the teachers used different strategies for helping their students do well. Alex used a number of other things maintaining, “in this class if they just do their homework and they do the projects and they attend class they could actually have a D and still make somewhere in the 50s on a test” (AI2: 419-421). Patrick ensured that there were other avenues for students to earn decent grades even if they were poor test-takers, averring, “I grade everything. They get a homework grade, they get a class work grade, and they get a lab grade, a test grade and a quiz grade.” (PI4: 253-255). George also explained, “I try and curve things and stuff” (GI1: 237).
Assessment concerns were mentioned by all participants. High stakes testing was important to the four public school teachers. Alex hoped that his students be able to do well but worried that they had reading weaknesses and were poor test-takers. Meredith used warm-ups at the beginning of class to teach her students test strategies stating “I like doing [high-stakes test] questions because … I keep thinking that if I go through and show them enough different ways that I look at them then they will catch on” (MI2: 55-57). Isobel used a bulletin board in the front of class to expand her student’s science vocabulary for the high-stakes test and would quiz students on the words and their meanings (IO1). Patrick taught test strategies and maintained “You know that’s the reason why I try to fire off those key things and I will bring those up again those things will be on the test and they know that too” (PI3: 55-57).

All six of the teachers were concerned with student grades. Patrick had a specific formula of percentages for each type of student work. “I grade everything” (PI4: 253) he stated and gave extra credit projects to help his students bring their grades up. George graded on the curve, a practice that was unique to him (GI1: 237). Isobel, in alignment with her process orientation, felt that if students did their homework, their grades would reflect their effort (II2: 69-71). Alex focused on what grades students were carrying and was very proud that two of his students with special needs were carrying a B and C, respectively (AI2: 128-131).

Other types of assessment were mentioned by all participants. Alex stated that “class participation gets them a test grade” to help raise student grades that were low from test scores (AI3: 305). George and Isobel had an essay as part of their assessment and Cristina was having her students write a research paper, one of her goals for her students (CI1: 265-268). Formative assessments were used by Patrick, Meredith, Alex and Isobel and they ranged from crossword puzzles and other seatwork and homework to questioning, discussion, and exit tickets.
Instructional Strategies

Instructional strategies are defined as techniques that are used for successful teaching including textbook strategies, kinesthetic activities, and presentation methods. They are one of the visible parts of a teacher’s orientation to teaching science. Six participants were interviewed and observed, data were analyzed and categories created to organize their responses. Three categories emerged across the individual cases: teacher-led strategies, student-led strategies, and group strategies. A definition for each category is presented in the corresponding subsection below and a summary of their instructional strategies is listed on Table 5-13.

### Table 5-13. Participant’s instructional strategies.

<table>
<thead>
<tr>
<th>Teacher-led Strategies</th>
<th>Patrick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture, note taking and demos</td>
<td>Discussion, use internet</td>
</tr>
<tr>
<td>Lecture, note taking and demos</td>
<td>Lecture, scenarios, and labs</td>
</tr>
<tr>
<td>Lecture, note taking, and seating plans</td>
<td>Discussion, demos</td>
</tr>
<tr>
<td>Storytelling, lecture, note taking, and demos</td>
<td></td>
</tr>
<tr>
<td>Student-led Strategies</td>
<td>Meredith</td>
</tr>
<tr>
<td>Compare/contrast, activities</td>
<td>Lab aids, and labs</td>
</tr>
<tr>
<td>Activities, labs</td>
<td>Lab aids, and labs</td>
</tr>
<tr>
<td>Labs, activities, and projects</td>
<td></td>
</tr>
<tr>
<td>Group Strategies</td>
<td>Alex</td>
</tr>
<tr>
<td>Teacher assigned members; size varied based on materials</td>
<td>Students picked groups; size varied based on materials</td>
</tr>
<tr>
<td>Students picked groups</td>
<td>Students picked groups; preferred small groups</td>
</tr>
<tr>
<td>Students picked groups</td>
<td>Students picked groups; lab groups of two students</td>
</tr>
<tr>
<td>Students picked groups; size varied based on task</td>
<td></td>
</tr>
</tbody>
</table>

### Teacher-led strategies

Teacher-led strategies are those teaching techniques in which the teacher performs the strategy. Lecture and note-taking was used as a strategy by four participants. Cristina explained, “I do not know any other way that you can teach the material” (CI1: 261-263). Patrick also used lecture and note taking as preferred strategies on a daily basis. George used lecture to get his
students to a point where they could discuss topics. Along with lectures, Alex used scenarios on a transparency and discussed the science problem presented with his students (AI2: 246-253).

Demonstrations were used by five of the participants. Patrick demonstrated musculature by dissecting chickens and showing his students the different muscle groups (PO4). An interactive web site on mitosis and meiosis gave Meredith a powerful demo (MO3). Alex built his own demonstration materials for his lesson on trajectories (AI2: 379-381). Isobel used a student demo, crushing aluminum cans, to demonstrate the power of air pressure (IO4). “There are always little things you can do,” (GI1: 77) George stated discussing how demos helped his students to visualize better.

**Student-led strategies**

Student-led strategies are those teaching techniques in which the student performs the activity. All participants used student-led strategies. Isobel and Meredith liked using compare and contrast activities, Meredith with a Venn diagram to cement student’s understanding of the difference between meiosis and mitosis (MI2: 180-183) and Isobel having her students write about the similarities and differences in particular environmental pollutants such as radon (II1:263-265). Alex had his students make a slide from cork slices and view it in the microscope (AO2). Patrick had his students make large charts of the body muscles (PO1). Cristina used a lab aid she had purchased to help explain genetics (CO3). George liked to use the LCD projector but as it was broken drew diagrams from the book on types of geologic faults (GI3: 78-79).

Four teachers used labs as a preferred instructional strategy. George and Alex had students perform one lab per chapter. Isobel assigned her students to perform labs weekly. Patrick had his students complete labs to cement concepts or as a prolonged activity like the owl pellets prey skeleton project.
**Grouping strategies**

Grouping is a student-led teaching technique that groups students together to perform a task. Grouping is used by all of the beginning teachers however participants used different strategies to accomplish the strategy. Patrick had class rules for groups and tried to mix genders and ethnicities. Patrick assigned members to a group and stated “the groups are picked earlier in the year when we did some lab groups where they’ve stayed relatively the same” (PI2: 85-86). Cristina also assigned members to groups. Allowing their students to pick their groups was a technique shared by Meredith, Isobel and George. “When we have them work in groups they will switch partners back and forth” (II4: 134) Isobel maintained. She also used her groups to teach students to work together, one of her goals.

Size of groups was an issue my participants spoke of with their ideas ranging from big to small. Cristina liked small groups with no more than two members as she commented that “the bigger the group the more out of control it gets” (CI1: 121-122). George used all sizes of groups from half the class when he wanted competition to pairs for experiments. He felt that three was a good number for normal groups, with any more members causing his 7th graders to lose control (GI2: 145). Patrick also used varying group sizes based on how many materials he had as did Meredith.
CHAPTER 6
DISCUSSION AND IMPLICATIONS

This chapter begins with a discussion of the current study followed by a summary of the results. The results are presented in relationship to research questions along with a discussion of limitations and implications for teacher education. Recommendations for further research are posed in the conclusion to this chapter.

Overview of the Study

In this study, six secondary science teachers beginning their careers as educators in public and private schools were studied to describe their conceptions of teaching science. Their CTS consisted of their beliefs and knowledge about their subject, learners, learning, teachers and teaching. The study was grounded in research that investigated teacher thinking, pedagogical content knowledge (PCK), orientations to teaching science (OTS), conceptions of teaching science (CTS), and traditional and alternative routes to certification. Hewson and Hewson’s (1988) study of teacher’s conceptions of teaching science provided the framework for examining the teachers’ beliefs about teaching and the conditions necessary for effectiveness. They stated, "science teaching should of necessity consist of tasks and activities which are intended to help particular students learn particular content . . . indicative of the particular content to be learned, and expressed so that it is possible for the particular students to learn it" (Hewson & Hewson, 1988, p. 601) and gave characteristics that a teacher should possess in order to be effective.

I further analyzed the six participant’s goals for teaching science, planning, preferred instructional techniques, and assessment strategies (called orientations to teaching science). Data analysis of the six beginning secondary science teachers revealed that six of Magnusson, Krajcik, and Borko’s (1999) nine orientations to teaching science, that is, process-driven, activity-driven, academic rigor, didactic, project-based science, and guided inquiry orientations were consistent
with my teacher’s orientations to teaching science. Research also confirmed findings first presented in Friedrichsen’s (2002) study of experienced biology teachers that her teachers’ orientations were teaching strategies (such as lecture or discussion) chosen depending on what they felt were their goals for teaching science.

Specifically, this study addressed the following research questions:

- **Research Question 1:** What are the conceptions of teaching science of the six beginning secondary science teachers in this study?

- **Research Question 2:** What is the nature of orientations to teaching science of the six beginning secondary science teachers in this study?

- **Research Question 3:** To what extent does CTS and OTS help elicit beginning science teachers thinking (PCK)?

**Review of Methods**

A multiple case study of six beginning secondary science teachers in their first year teaching in public and private schools was conducted and data were analyzed to describe how participant’s conceptions of and orientations to teaching science influenced their teaching behaviors. Descriptions were based on data collected over a five-month period (October 2005 to February 2006). Included in the data collection procedures were three sources of data: beginning science teacher’s interviews, the Task for Identifying Conceptions of Teaching Science (Hewson & Hewson, 1989) interview, and classroom observations chosen in order to provide multiple data sources to attempt to answer the research questions.

Hewson and Hewson’s (1989) Task for Identifying Teacher’s Conceptions of Teaching Science presented each beginning secondary science teacher with teaching scenarios from their science field and asked whether it was an example of teaching or not, providing instances and non-instances of science teaching in and out of class. The task was analyzed using seven categories suggested by the data, that is, a teacher’s characteristics for successful teaching,
whether they felt teaching was happening, teacher’s understanding of the nature of science, whether they felt learning was happening, what learner characteristics were involved, conditions for teaching and learning, and their preferred instructional techniques as outlined in Hewson and Hewson’s (1989) study.

To analyze all other observation and interview data I used thematic network analysis (Attride-Stirling, 2001). This type of analysis attempts to interpret text to find the themes within it at three different levels, basic, organizing, and global. After the three thematic levels were extracted from the data they were placed in a concept web or thematic network and described and summarized in a report (Attride-Stirling, 2001). The interview and observation data collected generated codes which I used to identify basic, organizing, and global themes (Attride-Stirling, 2001). At this point, I developed a thematic network using symbols, arrows and text to illustrate each global theme and its corresponding organizing and basic themes. These thematic networks were concept maps for each participant’s conception of teaching science, orientation to teaching science, and the possible sources for their OTS.

Cross-case analysis was conducted to identify patterns across the six cases. I used the thematic networks to re-read the data within the context of the three levels of themes, basic, unifying and global. Summarization of the thematic network(s) brought out principle themes and patterns in the data (Attride-Stirling, 2001). These themes (Appendix H) suggested patterns in the data which became the basis for the findings reported about the research questions.

**Findings and Discussion**

All findings relate to the research questions presented on the second page of this chapter and are based upon the case studies of the six beginning secondary science teachers. The findings of the individual case studies are presented in Chapter 4 and cross-case analysis of the studies is presented in Chapter 5. My findings were organized around the basic, unifying, and global
themes emerging from the data and developed into thematic networks which fell naturally into
the constructs identified by Hewson and Hewson (1989) and Magnusson et. al (1999).

**Research Question 1**

What are the conceptions of teaching science of the six beginning secondary science
teachers in this study?

Hewson and Hewson (1988) introduced the conception of teaching science and gave it five
components, that is, conceptions of science, conceptions of teaching, learner characteristics,
rationale for instruction, and preferred instructional techniques (Hewson & Hewson, 1989).

Seven components of a teacher’s Conceptions of Teaching Science, that is, teacher
characteristics, teaching, conceptions of science, learning, learner characteristics, conditions for
teaching/learning, and preferred instructional techniques, were suggested by the data. Each
teacher’s beliefs about these components came together in a picture of the participant’s
conceptions of teaching science. Table 6-1 is a summary table of whether each participant’s CTS
is teacher- or student-centered and a statement of their conceptions of teaching science.

<table>
<thead>
<tr>
<th>Table 6-1. Participant’s Conception of Teaching Science.</th>
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<tbody>
<tr>
<td>Teacher or Student Centered Conception</td>
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<tr>
<td>Teacher-centered</td>
</tr>
<tr>
<td>Conceptions of Teaching Science</td>
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</table>

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**Teacher- or student-centered conception**

Kember (1997) looked at thirteen research studies to determine academics’ conceptions of teaching. He categorized the academics described in each study as on a continuum ranging from “teacher-centered/content oriented” to “student-centered/learning oriented” and saw this continuum as from “knowledge transmission” to learning facilitation” (p. 260). I used Kember’s categories of teacher- or student-centered to initially align my six teachers and realigned them choosing two of Koballa, Glynn, Upson and Coleman’s (2005) conceptions of teaching science to describe each participant.

A clear picture of each of the beginning science teacher’s conceptions of teaching science developed from the data. Half of the participants espoused a teacher-centered conception of teaching science and the learning environment in their classrooms reflected this orientation. This teacher-centered belief shared by the participants was what Roberts and Chastko (1990) termed absorption. He explained that teachers not having been exposed to methods classes tend to see science concepts as something to be learned as fact and not as a structure to guide other learning. Interestingly, this was not the case with two of my participants who were teacher-centered. Both saw science as human-generated and one believed it was tentative additionally.

Two participants viewed teaching as student-centered and both their CTS interview and later observation and interviews confirmed this. The final participant appeared to be changing her focus from teacher-centered toward student-centered science teaching. During her CTS interview this participant’s conception of teaching science leaned toward teacher-centered but by the middle of the second semester when I observed and interviewed her, the learning environment in her class appeared student-centered. Dailey (2003) felt that the orientation of the teacher determined whether the learning environment was teacher-centered or learner-centered.
Conceptions of teaching science

Kember (1997) in his study found that teacher’s conceptions of teaching science were
teacher- or student-centered, that is, that it is best taught by transferring knowledge from teacher
to pupils, by posing problems for pupils to solve, or by interacting with pupils (p. 215). Koballa
and a group of researchers (2000) developed statements of teacher’s conceptions of chemistry
teaching based on Kember (1997). This is in alignment with Daily (2003) who describes five
different perspectives on teaching: transmission, apprenticeship, development, nurturing, and
social reform proposed by Pratt (1998; in Daily, 2003).

Koballa et al. (2005) in a later study found that participants in an alternative science
teacher preparation program held one or more of five conceptions of teaching science: 1) Presenting
science concepts to students, 2) Providing students with a sequence of science
learning experiences, 3) Engaging students in hands-on science activities, 4) Facilitating the
development of students’ understandings about science, and 5) Changing student’s science-
related conceptions. Since most of my participants were becoming alternatively certified
teachers, I chose to describe their conceptions of teaching science as Koballa et al. (2005)
deduced.

Each of my participants had a two or more conceptions to teaching science. Three of the
participants, all of which had a teacher-centered conception of teaching science fit into the
category of presenting science concepts to students. Two of the three participants also provided
students with a sequence of science learning experiences. The third participant was engaging
students in hands-on science activities. The final three participants, all of whom were student-
centered believed they were facilitating the development of student understanding about science.
Two of these participants additionally perceived they were changing student’s science-related
conceptions while the third believed she was providing students with a sequence of science learning experiences.

All participants possessed multiple conceptions to teaching science based on their beliefs about teachers and teaching, learners and learning, and perceptions about science including the nature of science. These perceptions caused them to present material and choose instructional strategies which were in alignment with their conceptions of teaching science.

**Research Question 2**

What is the nature of orientations to teaching science of the six beginning secondary science teachers in this study?

Magnusson, Krajcik & Borko (1999) suggested there were nine orientations to teaching science, that is, process, academic rigor, didactic, conceptual change, activity-driven, discovery, project-based science, inquiry, and guided inquiry (p. 100). Similarities and differences between the orientations to teaching science of each of the beginning secondary science teachers were evaluated and appear to be in alignment with six of Magnusson, Krajcik and Borko’s (1999) nine orientations. The six orientations were those of academic rigor, didactic, activity-driven, project-based and guided inquiry. A summary of participant’s Orientations to Teaching Science is listed on Table 6-2.

<table>
<thead>
<tr>
<th>Table 6-2. Participant’s Orientations to Teaching Science.</th>
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</thead>
<tbody>
<tr>
<td>Patrick</td>
</tr>
<tr>
<td>Didactic/academic rigor</td>
</tr>
<tr>
<td>Didactic/academic rigor</td>
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</tbody>
</table>

Specific orientations for each teacher were chosen using data collected about each of the six categories of Orientations to Teaching Science, namely a teacher’s goals for teaching, science curriculum, school context, beliefs about learner characteristics, rationale for instruction, and instructional strategies (Magnusson, Krajcik & Borko, 1999).
Didactic/academic rigor orientation

Two of the beginning teachers adopted a didactic/academic rigor orientation which consisted of them having a formal, authoritarian presence in class and presenting the material mainly through lecture and note-taking. Activities and labs were performed with strict attention to detail and with rigorous standards and were confirmative in nature, reaffirming a concept or piece of knowledge. Both relied heavily on students memorizing scientific terminology and concepts as a means of developing content knowledge. Testing was the major component of their student’s grade. Goals for their students were focused on academic preparation and developing a good science base. Both of these teachers were in the process of being alternatively certified, had strong mentor relationships with their college professors and had left the academic environment six months before beginning secondary science teaching, one having completed her degree six months before starting her teaching career and one leaving a coaching position in a college setting the summer before starting teaching. Both teachers had planned continuing studies at university but had to change plans, one due to loss of funding and one due to a spouse moving to another state. Could having professors as mentors and recent ties with academia have led them to develop a didactic/academic rigor orientation?

Process/guided inquiry orientation

Two of the beginning teachers (one-third of the participants) had or were developing a process/guided inquiry orientation to teaching science. Both preferred an informal presence in class and felt that their students were responsible for their learning and grades which reflected their process orientation. Both relied on technology and media to support their teaching and used many hands-on labs and other activities to stimulate their students’ interest in the subject as well as to help students develop understanding of content which reflected their guided-inquiry orientation. Both used formative assessment strategies such as observing or talking with the
students to determine the progress being made. Their goals were focused on student skill and science literacy as well as life skills such as teamwork and social skills.

**Project-based orientation**

One teacher had a project-based orientation to teaching science. His presence in class was informal but he was more of a coach to his students, developing projects to help them acquire understanding of the natural world and how people interact with it. This teacher supported discussion in his class and encouraged his students to ask questions. It was natural for him to place his students in groups to work on homework, activities or projects. His goals for his students reflected his desire to integrate concepts and explore real-world examples for his students. Although focused on his students developing good science content knowledge, he also wanted students to be interested in a career in science and to develop excitement for science. Additionally he wanted academic achievement for his students or “put their best effort” into school. All of his mentors were high school coaches and he seemed to emulate them.

**Activity-driven orientation**

The last participant had an activity-driven orientation to teaching science which caused him to maintain an authoritarian presence in the class which was more teacher-focused. He chose his hands-on activities based on concerns for classroom management. Everything for his students was visual and kinesthetic from the scenarios and terminology he displayed on transparencies to his style of breaking information down and giving everything a focus on what he termed the “modern world.” This paralleled one participant from Koballa and Coleman’s (2005) study who had an activity-driven orientation.

Teaching strategies encompassed demonstrations which the students could touch and operate, group activities and labs. Everything he taught was standards-based and directed towards his students passing their high-stakes tests. He used questioning as an assessment and
his tests were self-analyzed to ensure that they were not too hard. This teacher-participant had been out of school for thirty plus years and followed the dictates of the mentors in his alternative certification program, his school mentors, and the guidance of the book to help him teach science concepts.

Research Question 3

To what extent does CTS and OTS help elicit beginning science teachers thinking (PCK)?

Both conceptions of teaching science (CTS) and orientations to teaching science (OTS) contain three elements in common, that is, learner characteristics, rationale for teaching and preferred teaching strategies. In the model for conceptions of teaching science the rationale for instruction and preferred strategies are seen as two of its five components whereas in the model for orientations toward teaching science they are seen as the evidence that exemplifies a teacher’s goals for teaching (Magnusson et al., 1999). The conceptual framework I designed by combining conceptions of teaching science and orientations to teaching science shows the intersection between CTS and OTS and their shared components (Figure 6-1). Exploring the nexus between a beginning teacher’s orientations to teaching science and conceptions of teaching science helps to fully illustrate the beginning teacher’s thinking on secondary science instruction.

Teacher-centered conception to teaching science and subsequent orientations

One half of the teacher participants had a teacher-centered conception to teaching science. Since all of these teachers had had little to no education or pedagogy classes, they had little understanding of student characteristics and learning. One of the three beginning teachers saw students as unmotivated and untrustworthy. Another participant believed that motivation could only be determined by student response. The third participant felt his students were motivated but his actions in class belied this. He was constantly checking on his students when engaged in group activities to determine if they were “on task.”
All of the participants who had a teacher-oriented conception believed that age and cognitive level were important for student learning but were unsure of what abilities students had at different ages and grades. Every one of these participants felt that students came to class with almost no knowledge and felt that they needed to give students background knowledge before any learning could happen. Two of the three beginning science teachers believed that a teacher must be present for learning to occur and all strived for total control of the class.

Two of these three beginning teachers adopted a didactic/academic rigor orientation and presenting the material mainly through lecture and note-taking. One teacher stated, “I do not know any other way that you can teach” (CII: 261-262). Activities and labs were performed with
strict attention to detail and with rigorous standards and were confirmative in nature. The last teacher of this group had an activity-driven orientation to teaching science which caused him to maintain a teacher-centered presence in the class. Everything for his students was visual and kinesthetic and teaching strategies included labs and group activities along with interactive demonstrations in which the students could touch and operate the materials and equipment.

All three teachers focused on terminology and definitions as a center to their teaching and one stated when speaking of a teacher mentor, “I still to this day can tell you some of the definitions this man taught me in the ninth grade and I teach them to these students here” (AI1:108-109). All three of these participants had mentors who were either college professors or had been traditional high school teachers over thirty years before. I believe this had a huge influence on the rigid teaching styles of each of these participants and a study supports this finding that “secondary teachers with no pedagogical preparation had a limited ability to engage high school students in the subject matter and that those teachers taught as they had been taught” (Wilson, Floden, Ferrini-Mundy, 2002).

**Student-centered conceptions of teaching science and subsequent orientations**

The second half of teacher participants in the study had a student-centered conception to teaching science. One of these teachers had graduated from a teacher training program, another had four or five education and pedagogy classes as well as prior special education learning experience, and the third participant had two undergraduate and one graduate degree. It is possible that education courses gave two of the participants an understanding of student characteristics and learning. The third participant with a graduate degree is an anomaly. I can only surmise that she was able to develop the understanding of students and learning either from observation or from her business work and development of what she termed “soft skills.”
These beginning teachers saw students as motivated by the interest generated in class and worked to be interesting, exciting and entertaining. All believed that age and cognitive level were important for student learning and understood the different ages at which children understand and learn concepts. Every one of these participants felt that students came to class with prior knowledge and understanding and all three participants talked about students’ different learning styles, and misconceptions. All teachers believed that students could learn on their own, with their peers and through media, one expressing the awareness that learning was deep understanding and social.

Two of the beginning teachers had or were developing a process/guided inquiry orientation to teaching science. Both preferred an informal presence in class, felt that their students were responsible for their learning and grades and relied on technology and media as teaching strategies. Both used formative assessment and felt they could determine how a student was doing by observing or talking with them. Their goals focused on student skill, science literacy and life skills.

The third teacher had a project-based orientation to teaching science. His presence in class was informal as he was coach to his students, helping them to acquire understanding of the natural world and how people interact with it. He also encouraged his students to ask questions and naturally grouped them in the classroom. His goals for his students were focused on concept knowledge, student career interests and student’s developing life skills.

**Conclusion**

**Theoretical Framework Revisited**

Three key concepts of teacher’s thinking about their science teaching were the theoretical framework for this study. These concepts, that is, pedagogical content knowledge, orientations to
Pedagogical Content Knowledge

PCK, discovered by Shulman (1986) and refined by Grossman (1990) presented the structure for teacher thinking about science teaching. PCK, one of four categories of teacher knowledge, combined the components pedagogical knowledge and beliefs with content knowledge and beliefs using teacher experience to transform these into subject-specific pedagogical content knowledge (Figure 6-2). In this study I illustrated that by determining my six beginning secondary science teachers’ Conceptions of Teaching Science in conjunction with their Orientations to Teaching Science I could elicit my participant’s PCK.
Friedrichsen (2002), who studied the Orientations to Teaching Science of highly regarded biology teachers and developed a substantive-level theory based on her findings, found the greatest influence of PCK on her participants’ orientations to teaching science was the domain of knowledge and beliefs about the school context. The data in my study showed that the beginning secondary science teachers I studied were influenced mainly by the PCK domain of subject matter knowledge and beliefs.

Figure 6-2. Model of domains of teacher knowledge in PCK. Modified from Magnusson, Krajcik and Borko (1999)
Content knowledge as described by Abd-El-Khalick and Boujaoude (1997) is a teacher’s knowledge and understanding of the facts and concepts of the particular science they teach filled with the relationships among scientific facts, concepts, and procedures (p. 675). A global understanding of how a particular science is broken down into concepts and how this branch of knowledge fits in with other fields of science is an important part of developing PCK.

The traditionally certified teacher in this study mediated the content knowledge domain shown in Figure 6-2 with her pedagogical knowledge and beliefs. To a lesser degree this appeared to be the case of two other participants, one who had taken four or five education and pedagogy classes and the other who had two undergraduate and one advanced degree in science.

The other three beginning teachers in the study mediated the subject matter knowledge and beliefs domain with knowledge and beliefs about context, specifically their beliefs about students and the school they taught in. Their beliefs about students appeared to come from their own experiences as students. Those teachers who had no pedagogical training seemed to rely on the beliefs about teaching and learning garnered from their own learning experiences and mentors.

The six new teachers I interviewed and observed were very focused on presenting students with their learned science content knowledge. Studies (Koballa, Glynn, Upson & Coleman, 2005; Lemberger, Hewson, & Park, 1999) show that it takes beginning teachers up to three years to develop ways in which to teach content effectively which is pedagogical content knowledge (Figure 6-2).

Were the participants in my study influenced by subject matter knowledge and beliefs due to recent graduation from their university or was it due to their inexperience with teaching? I feel that it was a combination of factors. One influence could be recent graduation from or association with a university. Two of my participants had a tendency to try to present too much
knowledge to the student at one time. They mentioned that they had to break down the knowledge into smaller parts for their students to understand. One was a recent graduate and the other had been employed by a university in a coaching and teaching capacity a few months prior to beginning his K-12 teaching career. Other participants, both with traditional and alternative certification, talked about struggles finding the right strategy to present information to their students.

A second influence I believe is lack of experience working with children. In a traditional teacher education program, pre-service teachers are given experiences in both observing and teaching students. Five of my participants were becoming alternatively certified and only one of them had prior experience teaching undergraduate classes at university and teaching elementary children science part-time. Only one of my beginning teachers was traditionally certified and taught high school science for a semester supervised by a cooperating teacher. This lack of meaningful/focused interactions with students may have caused participants to rely on their perceptions of student behavior during their own years as learners instead of having experience dealing with contemporary students.

A third influence would be the participant’s perceptions of their school context. The public school systems where I observed four of the candidates were standards-based focusing strongly on high-stakes testing to determine student’s academic preparation. Additionally, since the passing of the No Child Left Behind Act, the national trend for highly qualified teachers stresses subject matter knowledge as more important than pedagogy (Darling-Hammond, Berry& Thoreson, 2001; U.S. Department of Education, 2001). The final two participants were teaching in private schools, environments which were college preparatory-focused with subject matter acquisition as paramount for students.
Combining Conceptions of Teaching Science and Orientations to Teaching Science

Magnusson, Krajcik and Borko (1999) found that one component of PCK controlled all others and named it Orientation to Teaching Science (Figure 6-3). Examining the six beginning secondary science teacher’s orientations to teaching science in conjunction with their

![Diagram of PCK and its components](image)

Figure 6-3. PCK and its components. Modified from Magnusson, Krajcik and Borko (1999).
conceptions of teaching science helped to give me a clearer understanding of the components involved in a teacher instructing in a particular subject to specific students. I was able to look at both the teacher’s beliefs about teaching science (CTS) and the way they taught based on their goals for teaching science (OTS) and to see how components of both, specifically beliefs about students and learning, rationale for teaching, and instructional strategies aligned each teacher’s conceptions of teaching science with their orientations to teaching science. I found that those teachers who had taken teacher education courses had more knowledge of students and how they learn, as well as teachers and how they teach, and used a larger variety of teaching strategies.

The five participants without any teacher education or training expressed concern about developing lesson plans. They struggled to process the information they had to teach and break it down into small enough pieces for students to process. Assessment was also a problem for those participants who were becoming alternatively certified and they relied on their textbook to help teach and assess their students. Developing learning activities and finding resources was also a problem for the teachers who had no prior training. They did not know where to find information or people who could assist them to develop these and again relied on the textbook, source books, the internet and their mentors for assistance.

My six participants’ conceptions of teaching science and the way they taught based on their goals or orientation for teaching science reinforced each other. Components of both, specifically beliefs about students and learning, rationale for teaching, and instructional strategies aligned each teacher’s conceptions of teaching science with their orientations to teaching science and determined where the six participants taught on a continuum from teacher-centered and content oriented to student-centered and learning oriented. Based on my findings I believe that conceptions for teaching science and orientations to teaching science should be
combined in one model (Table 6-4) modified from Friedrichsen’s model of science teaching orientations.

**Modifying Friedrichsen’s Model of Science Teaching Orientations to Combine OTS and CTS**

Friedrichsen (2002) developed a model to explain her theory of science teaching orientations which she called her Substantive Level Theory of Science Teaching Orientations (Friedrichsen & Dana, 2005). The findings from this study support Friedrichsen’s theory in part. I believe the differences were due to a different population of science teachers. Friedrichsen’s teachers were all traditionally certified with many years of experience whereas mine were all beginning teachers, the majority of which were becoming alternatively certified.

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**Figure 6-4.** Mayne’s emergent theory of beginning teacher’s PCK via their Conceptions of and Orientations to Science Teaching.
The differences I found were in my participant’s goals for teaching science, sources of means, and sources for teaching strategies. I have modified her model to represent what I discovered from the participants in my study (See Figure 6-4 above) entitled Mayne’s Insights into Beginning Teacher’s PCK via their Conceptions of and Orientations to Science Teaching.

**Perceptions of school context**

As most of the participants in my study were attaining alternative certification their perceptions of the requirements the school they taught in placed on them was a large part of how they perceived teaching. These perceived requirements, that is, time constraints, teaching issues, administrative requirements, high-stakes testing, and the performance orientation of their school placed constraints on how they taught and the activities they used to explain content.

**Beliefs about learners and learning**

Participants’ beliefs about learners and learning affected how they taught their students. One teacher in my study completed education and pedagogy classes, observed students in a classroom setting, acted as a substitute teacher and taught for one semester in a public school prior to starting her first year of teaching. She had many opportunities to develop or refine her original beliefs about learners and learning. Another participant had taken education and pedagogy classes as part of his undergraduate degree whereas a third participant had taught two undergraduate classes and some science activities in a local school elementary prior to teaching secondary science. The final three participants had no coursework or teaching experience and had to rely on their own learning experiences to develop their beliefs about learners and learning. As such they believed students to behave as students had during their previous learning experiences rather than as contemporary learners.
Beliefs about teachers and teaching

A teacher’s beliefs about teachers and teaching determine how they will teach and the strategies used during teaching. For most teachers in the study, their beliefs about teachers and teaching were based on their own experiences with teachers and mentors during their years as learners both in schools and at university. Those participants who had not experienced different teaching techniques or taken pedagogy courses taught the way they had been taught mediated but their beliefs of teachers and teaching. Two participants whose mentors were professors taught didactically. Another participant whose mentors were high school coaches coached his students. Participants whose mentors were process-oriented had a process orientation toward teaching.

Goals for teaching

All participants felt their most important science goal to be content knowledge. Each one gave it a different title such as students gaining a science base, science literacy, or preparation for the next science. I perceive this goal was driven by their beliefs about teachers and teaching and their school’s strong content-driven focus. My beginning science teachers had science goals of content knowledge which were a large part of their schools’ context. This goal was also influenced by the pressure of high-stakes testing and standards in the public schools and by college-preparatory emphasis in the private schools.

Most of the six participants in the study had both general and affective goals but these were not as important to them as general goals. This was a difference from Friedrichsen’s (2005) study of experienced biology teachers. Three of the participants held a general goal of academic success. They called it variously “to do well on the test” or “to shoot for an A” or “do the best you can.” Two participants, both with an academic rigor/didactic orientation wanted their students to have academic success. A general goal for four participants was that of developing student’s life skills.
Affective goals such as interest in science or excitement for science were also mentioned by five of the six participants. Four participants wanted their students to have excitement for science while one wanted students to develop an interest in science. There seemed no correlation between affective goals and whether participants held teacher- or student-centered orientations to or conceptions of teaching science.

**Rationale for instruction**

Due to the majority of the teachers in the study attaining alternative certification, they had little or no teaching experience to draw from as a source for their orientations to teaching science. This caused them to rely on prior learning experience and mentors. The two participants with college professor mentors had didactic and academic rigor orientations involving teaching strategies centered on lecturing and note-taking, whereas two of the beginning teachers with high school teachers as mentors had orientations and teaching strategies that reflected the teaching strategies of their teachers or coaches. Even the participants with process-driven orientations reported that they taught much like their former math and science high school mentors utilizing similar activities when lesson planning and types of assessment.

**Visible teaching strategies**

Due to lack of pedagogical training and classroom experience of my participants they relied more on the curriculum, textbooks, trial and error, and mentors for developing their teaching strategies whereas the traditionally certified teacher was able to use teaching strategies she had been taught and had observed during her training program. Could this have caused several of the teachers to assume an orientation that reflected their mentors? However this can also occur with pre-service teachers in traditional teacher education programs. Adams and Krockover (1997) stated that "the degree of translation from the program to the teacher’s
understanding of their classrooms appears to be modulated by their most significant learning experiences and the context of their teaching situations” (p. 649).

**Implications of the Study**

This research addresses an important issue of beginning secondary science teacher thinking specifically as relates to pedagogical content knowledge and its components conceptions of teaching science and orientations to teaching science. In addition, because of the large number of alternatively certified science teachers, this research has both theoretical and practical implications and also for further research.

**Theoretical Implications**

Pedagogical content knowledge (Shulman, 1986) is a construct for examining a teacher’s content-specific science teacher thinking. Due to the complexity of PCK, it is necessary to use tools to describe a teacher’s PCK at a particular period in time. Individually, tools such as Orientations to Teaching Science (Magnusson et al., 1999) and Conceptions to Teaching Science (Hewson & Hewson, 1988) will give a partial picture of an educator’s PCK. CTS and OTS complement each other and provide different areas of PCK, hence they are useful in tandem to understand a teacher’s PCK.

**Practical Implications**

During the traditional teacher education process, pre-service secondary science teachers need to examine their conceptions of and orientation(s) to teaching science. Explicitly examining pre- and in-service teacher’s CTS and OTS will allow them to reflect on the beliefs, goals and purposes they have for instruction and possibly realign them with more effective teaching strategies for their future classrooms. Inquiry-based teaching is the state (FL DOE, 2005) and federal standard (NRC, 1996) for science and needs to be modeled and explicitly taught to pre-service teachers. Instructors modeling science inquiry with appropriate instructional strategies
and assessment techniques will allow pre-service and in-service teachers to observe teaching which develops deeper student understanding of science concepts.

Teachers in alternative certification programs should also be required to examine their CTS and OTS. Due to the large number of candidates who are entering the teaching profession without any form of teacher certification, there is a huge need to teach them pedagogical knowledge and techniques, preferably before they enter the classroom. There are many university-based alternative certification programs which require coursework prior to teaching (Darling-Hammond, Berry & Thoreson, 2001; Cavallo, Ferreira & Roberts, 2005). A report from these programs indicate these teachers felt more prepared to develop curriculum, use teaching strategies and meet student’s learning needs. To enhance the quality of these other alternative certification programs, experiences should be provided for the teacher candidates to examine both their CTS and OTS In addition more quality alternative certification programs need to be instituted due to the large number of science teachers entering the profession without benefit of teacher education.

Principals working with new teachers and specifically those who are becoming alternatively certified need to institute a strong mentoring program to provide experiences for them to quickly develop well grounded understanding of the school context/culture to be able to navigate the requirements while developing strategies for effectiveness. Beginning teachers need access to experienced teachers to observe their teaching, and share materials and effective science learning activities. Time for beginning science teachers to reflect on their teaching and develop source persons and materials is also necessary to enable them to teach more effectively. Additionally they require a safe place to discuss their teaching experience. Ample opportunity
should be given new science teachers to talk about teaching: to share teaching experiences, and issues about time, equipment, materials for teaching with other new and experienced teachers.

**Further Research**

Overall this research study has provided much needed information about beginning secondary science teachers’ conceptions of and orientations to teaching science as an avenue to eliciting their PCK. However, the findings only provide a snapshot of participant’s PCK via their CTS and OTS. Both pre-service (Eich & Reed, 2002; Friedrichsen, 2001) and experienced (Friedrichsen, 2002) science teachers have been studied but there are few studies on beginning secondary science teachers. In addition there are studies on conceptions of teaching science both pre-service (Lemberger, Hewson, & Park, 1999) and in-service (Lyans, Freitag & Hewson, 1997; Hewson, Kerby & Cook, 1995) but little research done on novice teachers and especially those who are becoming alternatively certified (Koballa, Glynn, Upson & Coleman, 2005). There is a need to have longitudinal research into beginning teacher’s orientations to teaching science and conceptions of teaching science during their first three years of teaching while there are developing PCK.

More research with larger pools of novice teachers both traditionally and alternatively certified needs to be reported on. Findings from this research would increase understanding of how novice teachers develop and refine their conceptions of teaching science and how this shapes and refines their orientations to teaching science. With further research conducted using similar methods, educators may develop instructional methods and strategies that will lead to a deeper and more profound understanding of beginning science teachers’ beliefs of and goals for teaching science.
Final Thoughts

Teaching is complex and multifaceted, not just a simple one strategy, one teaching style proposition. Teachers need to know not only what to teach but how to teach and also to understand the nature of students they will be teaching. To understand the complex operation termed teaching, more researchers need to study the thoughts and actions of educators during their first months and years of teaching to determine the most appropriate experiences for them develop OTS and CTS consistent with effectiveness in the science classroom.
APPENDIX A
IRB-2 PROPOSAL AND INFORMED CONSENT FORMS

IRB-2 Proposal Form

1. **TITLE OF PROTOCOL**: Exploring Beginning Secondary Science Teachers Conceptions of and Orientations to Teaching Science (tentative)

2. **PRINCIPAL INVESTIGATOR(s):**
   Dina L. Mayne, doctoral candidate
   University of Florida College of Education
   School of Teaching and Learning
   2214 Norman Hall
   PO Box 117048
   Gainesville, FL 32611-7048
   (352) 392-9191 X241

3. **SUPERVISOR** (IF PI IS STUDENT):
   Dr. Rose M. Pringle, PhD
   School of Teaching and Learning
   University of Florida
   2412 Norman Hall, P O Box 117048
   Gainesville, FL 32611
   (352) 392-9191 x229 (voice)
   (352) 392-9193 (fax)

4. **DATES OF PROPOSED PROTOCOL**: From August 20, 2005 to May 20, 2006

5. **SOURCE OF FUNDING FOR THE PROTOCOL**: N/A

6. **SCIENTIFIC PURPOSE OF THE INVESTIGATION**: The study will explore the orientations to teaching science and conceptions of teaching science of first year secondary science teachers. We will investigate the following questions:

   1. What are beginning secondary science teacher’s conceptions of teaching science?
      a. What similarities and differences can be found between each teacher’s conceptions of teaching science?
      b. What similarities and differences can be attributed to their route to teacher preparation?
      c. To what extent is there congruence in teacher’s conceptions of teaching science with observed teaching strategies?

   2. What is the nature of beginning secondary science teacher’s orientations to teaching science?
      a. What similarities and differences can be found between each teacher’s orientations to teaching science?
b. What similarities and differences can be attributed to their route to teacher preparation?
c. To what extent is there congruence in teacher’s orientations to teaching science with observed teaching strategies?

7. The study will consist of a series of five semi-structured interviews and three to five classroom observations. In the first interview, biographical information and contextual information about the school setting will be gathered and Hewson and Hewson’s Task for Identifying Conceptions of Teaching Science (1989) will be administered. The second through fourth interviews will follow classroom observations of the participant teaching science. In these interviews, the participant will be asked to reflect on the activities that occurred during the observation period. Another interview will occur at the end of the observation period and will be used to attempt to clarify information garnered previously. Participants will be asked to check interview data for correctness. All interviews will be conducted in the school building of each participating teacher.

8. POTENTIAL BENEFITS AND ANTICIPATED RISK.
There are no known risks to the participants. By participating in the study, subjects may gain a better understanding of their own concepts of and purposes for teaching science. This increased understanding may lead to a more well-developed conception of teaching science.

9. DESCRIBE HOW PARTICIPANT(S) WILL BE RECRUITED, THE NUMBER AND AGE OF THE PARTICIPANTS, AND PROPOSED COMPENSATION (if any):
The participants will be recruited through a nomination list developed by the principle investigator. The criteria for selection will be that the participants are starting their first year of teaching middle or high school science and are either graduates of a traditional university teacher certification or alternative certification program. All participants will be over eighteen years of age. There is no proposed compensation.

10. DESCRIBE THE INFORMED CONSENT PROCESS. INCLUDE A COPY OF THE INFORMED CONSENT DOCUMENT
All participants who express an interest in participating in this study will be individually interviewed. During the interview, I will verbally explain the proposed study in detail. If the individual is interested in participating in the study, I will give them an informed consent form. The informed consent form will be read by me to these individuals. Participants will sign the form to signify their consent to participate in the study and be given a copy of the form for their own records.

Please use attachments sparingly.

__________________________
Principal Investigator's Signature

_________________________
Supervisor's Signature
I approve this protocol for submission to the UFIRB:

____________________________________
Dept. Chair/Center Director Date
Informed Consent Form

Protocol Title: Exploring Beginning Secondary Science Teachers Conceptions of and Orientations to Teaching Science (tentative)

Please read this consent document carefully before you decide to participate in this study.

Purpose of the research study:
The study will explore the orientations to teaching science and conceptions of teaching science of first year secondary science teachers.

What you will be asked to do in the study:
You will be asked to participate in a series of five semi-structured interviews and three to five classroom observations at your school. In the first interview, your biographical information and contextual information about the school setting will be gathered. You will also perform a task for identifying your conceptions for teaching science. The second through fourth interviews will follow classroom observations. The final interview will occur at the end of observation period. All interviews will be conducted in the school building of each participating teacher.

Time required: approximately 20 hours

Risks and Benefits:
There are no anticipated risks. By participating in the study you may gain a better understanding of your concepts of and purposes for teaching science.

Compensation:
There is no compensation or other direct benefits to you as a participant in this study.

Confidentiality:
Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number. The list connecting your name to this number will be kept in a locked file in my faculty supervisor's office. When the study is completed and the data have been analyzed, the list will be destroyed. Your name will not be used in any report.

Voluntary participation:
Your participation in this study is completely voluntary. There is no penalty for not participating.

Right to withdraw from the study:
You have the right to withdraw from the study at anytime without consequence.

Whom to contact if you have questions about the study:
Dina L. Mayne, Doctoral Candidate, School of Teaching and Learning, College of Education, 2214 Norman Hall, PO Box 117048, Gainesville, FL 32611-7048, (352) 392-9191 X241.
Whom to contact about your rights as a research participant in the study:
UFIRB Office, Box 112250, University of Florida, Gainesville, FL 32611-2250; ph (352) 392-0433.

Agreement:

I have read the procedure described above. I voluntarily agree to participate in the procedure and I have received a copy of this description.

Participant: ________________________________ Date: ______________

Principal Investigator: ______________________ Date: ______________
APPENDIX B
FIRST SEMI-STRUCTURED INTERVIEW PROTOCOL

Purpose of the Interview

1. Explain the purpose of the study.
2. Develop a trusting relationship with the participant.
3. Gather background information to construct a biography of the participant.
4. Collect contextual information that may be useful in analyzing the possible sources of the individual’s orientations to and conceptions of teaching science, and
5. Begin to solicit data on the participant’s individual’s orientations to and conceptions of teaching science by administering Hewson and Hewson’s Task for Identifying Conceptions of Teaching Science (1989).

Initial Interview Tasks

1. Explanation of the study.
   a) Define terms “conceptions of teaching science” and “orientations to science teaching.”
   b) Describe the extent of the participant’s involvement, that is, number of interviews, tasks, classroom observations, etc.
   c) Explain what I hope to learn from this study.
   d) Discuss what the participant may gain from the study, that is, increased awareness and understanding of their orientations to and conceptions of teaching science and the pedagogical content knowledge they use to guide their practice.
2. Ask participant to share their interest in being part of this study.
3. Ask participant to read and sign the informed consent form.

Interview Questions

1. Please tell me your name, what degree you have and when you received it?
2. What is your current teaching assignment?
3. Did you have an internship? If so, what science courses did you teach?
4. Tell me about your background in science.
   a) College science courses?
   b) What areas of science did you concentrate on or specialize in? What areas are your favorite(s)?
   c) Did you have graduate coursework in science?
   d) Have you any experience conducting scientific research? Or lab tech work?
5. Describe your teacher education program.
   a) Have you taken any graduate courses in education?
   b) In what ways did your teacher education program influence the way that you teach?
6. Why did you decide to become a science teacher?
7. Describe any role models that may have influenced your teaching style.
8. In your first weeks of teaching, can you recall a lesson that really went well? What were you teaching? How were you teaching it, that is, what teaching style, activities, questioning techniques were you using?
9. In your first weeks of teaching, can you recall a lesson that went really poorly? What were you teaching? How would you change teaching style, activities, questioning techniques, etc. to make it a successful lesson?

10. What goals do you have for your students in science? What areas of your science subject do you want to cover in your classes this year? Why do you think those areas are important?

11. What unit(s) are you currently teaching? What purposes or goals do you have for your students in this unit?

12. What curriculum are you using in your teaching? Are you satisfied with the focus of the curricular materials or text? Have you used other curriculum or texts to teach this subject?

**Task for Identifying Conceptions of Science Teaching (30 minutes)**

Have teacher read scenarios about specific real-world instances of science teaching and learning (Appendix F) one at a time, and ask protocol questions after instance.

**Protocol questions** (Peter W. Hewson & Hewson, 1989)

1. In your view, is there science teaching happening here?

2. If you cannot tell, what else would you need to know in order to be able to tell? What would this information tell you? Please give reasons for your answer.

3. If you answered ‘yes’ or ‘no’, what tells you that this is the case? Please give reasons for your answer.

**Closing Comments**

Could we schedule the first classroom observation and interview?
APPENDIX C
SECOND THROUGH FOURTH SEMI-STRUCTURED AND INTERVIEW GUIDE
PROTOCOL

Purpose of the Interview

To elicit and elaborate on participant’s knowledge and beliefs about the purposes and goals for teaching science by reflecting on class activities that occurred during the observation.

Interview Questions and Guide

1. What aspects of today’s lesson would you say best support your goals and purposes for teaching science? How?

2. Reflect on other aspects of the lesson and how they supported your purposes and goals for teaching:
   - teaching strategies
   - choices of activities
   - students’ understanding of the topic
   - student grouping
   - teacher-student and student-student interactions

3. How do you plan for:
   - this lesson
   - an entire unit
   How does this lesson fit into curriculum for the semester?

4. Have you ever taught this lesson before?
   - used different strategies
   - other strategies you might use when teaching it again

5. How will you assess student learning?
   - other tools used
   - tools you might use
   Why do you use that particular assessment tool?
   We need to schedule the next observation and interview.
APPENDIX D
FIFTH SEMI-STRUCTURED INTERVIEW PROTOCOL

Purpose of the Interview

To elicit and elaborate on participant’s knowledge and beliefs about the purposes and goals for teaching science by:
   a) reflecting on class activities and interactions that occurred during the study; and
   b) re-examining science teaching orientations and conceptions of teaching science.

Interview Questions

1. Looking back over the last month, what aspects of your classroom practice would you say best support your goals and purposes for teaching science? How?

2. Are there any aspects of your classroom practice that you feel detract from your goals and purposes for teaching science? Which ones and in what way do they detract?

3. What has been the least rewarding teaching experience this month? How has it affected your teaching?

4. What has been the most rewarding teaching experience this month? How has it affected your teaching?

5. Revisit your goals for teaching science. Have these goals changed or their priority?

6. Look at your student population. Have your teaching practices changed based on what you perceive as the needs of your students? How?

Final Thoughts and Closure of Study

Thank you for participating in this study. I will be analyzing data and writing for the next several months.

Would you be willing to check the transcripts of my interviews with you for accuracy?
APPENDIX E
CONCEPTIONS OF TEACHING SCIENCE INTERVIEW PROTOCOL

(Hewson & Hewson, 1989)

Task Protocol

1. In your view, is there science teaching happening here?

2. If you cannot tell, what else would you need to know in order to be able to tell? What would this information tell you? Please give reasons for your answer.

3. If you answered ‘yes’ or ‘no’, what tells you that this is the case? Please give reasons for your answer.
Instances about Biology

1. Teacher in 9th grade at the start of a topic on arthropods, passes around a box of specimens containing insects and spiders. Teacher asks, “what can you tell me about these specimens?”

2. A student at home watching a TV program on the different species of buck in the Ngorongoro Crater in East Africa.

3. Two students in the library, doing calculations on problems concerning calorie values for different foods.

4. College professor lecturing on Darwin’s theory of natural selection to a group of first graders.

5. Teacher in front of ninth-grade biology class describing the steps in using the Punnett Square method of figuring genetic offspring ratios.

6. Teacher reads a biology student’s statement that tomatoes are vegetables and asks, “is there any difference between biological definitions of fruits and everyday definitions of fruits and vegetables?”

7. Teacher, at the end of a demonstration of the skeleton, distributes a drawing and asks students to label the main bones from memory.

8. Junior high school student in class looking at a chart showing arterial blood as red and venous blood as blue, asks the teacher “how does the blood change color?”

9. A student at home following a recipe for blueberry muffins.

10. A teacher, writing a self-study resource center program at home on using a balance to measure the mass of an object.
Instances about Physics

1. Teacher in a middle school at the start of a topic on crystals, asking the class, “what can you tell me about the crystals I’ve passed around the class?”

2. A student at home watching a TV program on the use of solar power in generating electricity and heating homes.

3. Two 11th grade students in the library working on a set of kinematics problems from the physics textbook given for homework.

4. College professor lecturing on Einstein’s special theory of relativity to a small group of first graders.

5. Teacher in front of an 11th grade physics class, describing the steps used in the ‘free body’ method of solving dynamics problems.

6. Teacher reads an 11th grade physics student’s statement that ‘the current leaving the bulb is less than the current entering it’ and asks “what happens to the current inside the bulb?”

7. Teacher, at the end of a demonstration of magnetic induction using a model of a transformer, distributes a drawing and asks students to label the apparatus used in the experiment from memory.

8. Junior high school student in class, holding a polystyrene cup containing iced water saying, ‘the cup really prevents the cold from getting into my hand.’

9. A student at home following a recipe for blueberry muffins.

10. A teacher, writing a self-study resource center program at home on using a triple beam balance to measure the mass of an object.
Instances about Chemistry

1. Teacher in a middle school at the start of a topic on crystals, asking the class, “what can you tell me about the crystals I’ve passed around the class?”

2. A student at home watching a TV program on chemical plants which produce new plastics from coal.

3. Two 11th grade students in the library working on a set of vapor pressure problems from the chemistry textbook given for homework.

4. College professor lecturing on molecular orbital theory of relativity to a small group of first graders.

5. Teacher in front of an 10th grade chemistry class, describing the steps used in the factor-label method of solving mass-mass problems.

6. Teacher reads a 10th grade chemistry student’s statement that ‘ideal gases have no volume’ and asks “were you referring to the gas particles or the gas as a whole?’

7. Teacher, at the end of a demonstration of electrolysis of water, distributes a drawing and asks students to label the apparatus used in the experiment from memory.

8. Junior high school student in class, watching an experiment on the electrolysis of water that has been going on for some time, asks the teacher, ‘do you think you’ve got all the oxygen out of there yet?’

9. A student at home following a recipe for blueberry muffins.

10. A teacher, writing a self-study resource center program at home on using a triple beam balance to measure the mass of an object.
Instances about Earth/Space Science
(developed by researcher using Hewson & Hewson’s 1989 Task Protocol)

1. Teacher in a middle school at the start of a topic on rocks, asking the class, “what can you tell me about the rocks I’ve passed around the class?”

2. A student at home watching a TV program on the use of geothermal power in generating electricity and heating homes.

3. Two 9th grade students in the library working on a set of problems on astronomical units and light-years from the earth/space science textbook given for homework.

4. College professor lecturing on the Kepler’s Laws of Planetary Motion to a small group of first graders.

5. Teacher in front of a 9th grade earth/space science class, describing the steps used in calculating the daily, monthly, and annual mean, and annual range of temperatures in a specific geographical location.

6. Teacher reads a 9th grade earth/space science student’s statement that ‘ocean trenches are sites where slabs of oceanic crust are bent and move downward into the upper mantle’ and asks ‘why does subduction volcanism occur at these sites?’

7. Teacher, at the end of a demonstration of stellar classification using the Hertzsprung-Russell diagram of intrinsic stellar properties, distributes a drawing and asks students to label the different classes of stars on the chart from memory.

8. Junior high school student in class, after viewing a movie on the geologic time scale saying, ‘hunters must have had to use large weapons when killing dinosaurs because of their size.’

9. A student at home following a recipe for blueberry muffins.

10. A teacher, writing a self-study resource center program at home on using a triple beam balance to measure the mass of an object.
APPENDIX F
PERMISSION FORMS USED FOR RESEARCH IN LOCAL COUNTY SCHOOLS

Sample Application for Research Form Used for Gaining Access in County One

APPLICATION FOR RESEARCH IN _________ COUNTY PUBLIC SCHOOLS

Directions: Complete one application for each requested school. Attach IRB approval, if applicable, protocol and 1 copy of any instrument to be used. If research is to be grant-funded, please attach copy of grant. Turn in application to the Department of Research and Evaluation. You will be notified when action on this application has been completed.

Upon completion of your study, send one copy (or Word file) of Abstract to ________________.

Applicant Dina L. Mayne Phone (352) 332-3104 Date October 3, 2005
Address of Applicant 11305 NW 34th Avenue, Gainesville, FL 32606
Educational Affiliation University of Florida, College of Education, School of Teaching and Learning
Applicant is: Faculty ☐ Doctoral Student ☑ Master's ☐ Other (specify) ☐

Purpose of Research Study will explore the orientations to teaching science and conceptions of teaching science of first year secondary science teachers from both traditional teacher certification programs and alternate certification routes.

Title of Research Proposal Exploring Beginning Secondary Science Teacher’s Conceptions of and Orientations to Teaching Science

Brief summary of research proposal Study will consist of a series of five audio taped semi-structured interviews and five classroom observations with each of the teacher participants. The initial interview lasting 60 to 90 minutes will be used to explain the study, obtain background information on participants, and administer Hewson and Hewson’s Task for Identifying Conceptions of Teaching Science. Teachers will be observed during a one to two week period to obtain data on their teaching strategies, student-teacher interactions and selected activities. Short interviews scheduled after observations will be used to elicit teacher beliefs, goals, and their rationale for instruction. A closing interview will be scheduled to clarify information and participants will be invited to member check data for correctness. Supervisor of study is Dr. Rose Pringle, Assistant Professor, University of Florida, College of Education, School of Teaching and Learning, phone: 392-9191X229, rpringle@coe.ufl.edu, fax: 392-9193

Population needs: # of subjects 1 teacher Grade Level 6-12 science
Sex, age, race. ability level (s) open
School requested River Middle / High School Total time per teacher required approx. 10 hours
Total time per student required none – will be observing teacher and classes
Indicate additional school resources needed none
Dates applicant is to be in the school: October 15, 2005 – March 15, 2006

Data needed (list tests, surveys, information needed): none

If this application is approved, I agree to observe all legal requirements regarding the use of research and to submit an abstract or short summary of the research report to the School Board of ______ County, Research and Evaluation Department.

Applicant: ___________________________ Date: ________________
Signature:

Advisor/Dept. Chair: ___________________________ (if applicant is student) Date: ________________

SBAC Research Director: ___________________________ Date: ________________

School use only:

This application for research is: Approved: □ Not Approved: □ Principal's Signature: ___________________________

Remarks: __________________________________________

Contact person in school: ___________________________ Title: ___________________________
Signed Dissertation Proposal Used for Gaining Access in County Two

**UNIVERSITY OF FLORIDA**

College of Education  
School of Teaching and Learning

2403 Norman Hall  
P.O. Box 117048  
Gainesville, FL 32611-7048  
(352) 392-9191  
Fax (352) 392-9193

**DISSERTATION PROPOSAL**

<table>
<thead>
<tr>
<th>EdD</th>
<th>PhD X</th>
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</thead>
<tbody>
<tr>
<td>Student: Dina L. Mayne</td>
<td>UF ID#: 3164-8200</td>
</tr>
</tbody>
</table>

Dissertation Title: Exploring Beginning Secondary Science Teachers Conceptions Of And Orientation To Teaching Science

<table>
<thead>
<tr>
<th>Approved by Supervisory Committee Members:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>Rose Pringle, Ph.D.</td>
</tr>
<tr>
<td>Thomas M. Dana, Ph.D.</td>
</tr>
<tr>
<td>Richard Ferdig, Ph.D.</td>
</tr>
</tbody>
</table>

| Linda Behar-Horenstein, Ph.D. | External Member Signature |

Date Admitted to Candidacy: June 16, 2005

Anticipated Graduation Date: May 2006

REV:091905

An Equal Opportunity Institution
Dear Principal,

Presently I am a doctoral candidate at the University of Florida and am certified in Florida to teach chemistry as a secondary science teacher. Having attained my bachelor’s and master’s degrees in education at Wichita State University, I became certified to teach both middle and high school in the subjects of chemistry, physical science, earth/space science and general science in Kansas. I taught in the public schools there for six and one-half years before moving to Florida to enter the doctoral program. Prior to enrolling at UF, I taught in Alachua County in 2001, as both chemistry and integrated science teacher at Eastside High School. I have been fingerprinted and had a background check done prior to my teaching in Alachua County.

Because my specialization in Curriculum and Instruction at UF is science education, the study I have designed will explore the orientations to teaching science and conceptions of teaching science of first year secondary science teachers from both traditional and alternate teacher certification programs. To clarify some terms:

Conceptions of teaching science (CTS) refers to a teacher’s view of science as well as their “knowledge of the particular content to be taught, the particular students they will be teaching, and effective instructional strategies to plan and perform to achieve the intention of helping these students learn the desired content” (Hewson & Hewson, 1988, p. 611).

Orientation to teaching science (OTS) refers to teacher’s knowledge and beliefs about the purposes and goals of teaching science (Grossman, 1990; Magnusson et al., 1999).

Beginning secondary science teachers refers to individuals who are starting their first assignment as a science instructor in a middle school or high school environment.

In order to investigate how the beginning science teacher’s orientation to and conception of teaching science determines their rationale for teaching and instructional strategy; I am posing these questions to guide the data collection within the confines of the study:

1. What are beginning secondary science teacher’s conceptions of teaching science?
   a. What similarities and differences can be found between each teacher’s conceptions of teaching science?
   b. What similarities and differences can be attributed to their route to teacher preparation?
   c. To what extent is there congruence in teacher’s conceptions of teaching science with observed teaching strategies?
2. What is the nature of beginning secondary science teacher’s orientations to teaching science?
   a. What similarities and differences can be found between each teacher’s orientations to teaching science?
   b. What similarities and differences can be attributed to their route to teacher preparation?
   c. To what extent is there congruence in teacher’s orientations to teaching science with observed teaching strategies?

   I envision six teachers in the study and have three teacher participants at this time from _________ and _________ County. The methodology I will be using is a collective case study. Study participants for this research will be selected on the basis of their type of certification (traditional or alternate), subject certification (chemistry, physical science, earth/space science, physics, or biology), and their status as beginning teachers. Six to eight individuals who are beginning on their first year of teaching secondary science will be selected. Three to four of the participants will be from traditional university-based teacher certification programs. An additional three to four participants will be alternately certified first year secondary science teachers. Due to the specific requirements for my study, I am searching for applicants in your county at this time.

   The case studies will be about the teachers, so no student data will be used beyond grade level of students taught, number of students in class, and types of teacher-student interactions. My unit of analysis is beginning secondary science teachers in their first classroom assignment so my case study goal is to describe the case, beginning secondary science teachers’ orientations to science and conceptions of science as fully as possible. I am researching to determine specifically how beginning science teachers make sense of their experiences within the context of their beliefs and goals. I will act as interviewer and participant observer of the teachers as they develop experience teaching in their natural setting, the classroom.

   The data I collect will consist of observation and interview which will be interpreted within the context of each participant’s background. Data from this study will produce rich descriptive data about these beginning secondary science teachers, their beliefs, goals, and purposes of science instruction and their preferred instructional strategies.

   There will be a series of five interviews and five observations interweaved between the fours and last interview. The interviews and observations should take approximately two weeks for each teacher. If possible, I would observe and interview two teachers at a time at a specified point in their teaching, either the beginning or middle of an instructional unit. I will be using the standardized open-ended interview for the initial one or two interviews and the interview guide for post-observation interviews. For observations, I will be taking notes and will not video or audiotape any classes.
A complete analysis of the data in my case study should provide me with thick description of a group of beginning secondary science teachers’ conceptions of and orientations toward teaching science as they progress through the beginning of their first year teaching. As I will be doing with the ________ County School board I agree to observe all legal requirements regarding the use of research and to submit an abstract or short summary of the research report to the School Board of ________ County and any principals and teachers who may want it.

Dina L. Mayne
dmayne@ufl.edu
(352) 332-3104 home office
(352) 392-9191 X 254 UF office
### APPENDIX G

#### DATA COLLECTION SCHEDULE

Table G-1. Schedule of data collection.

<table>
<thead>
<tr>
<th>Contacts</th>
<th>Patrick</th>
<th>Meredith</th>
<th>Alex</th>
<th>Cristina</th>
<th>Isobel</th>
<th>George</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Explain study,</td>
<td>Explain study,</td>
<td>Explain study,</td>
<td>Explain study,</td>
<td>Explain study,</td>
<td>Explain study,</td>
</tr>
<tr>
<td></td>
<td>interview &amp; CTS task</td>
<td>interview &amp; CTS task</td>
<td>interview &amp; CTS task</td>
<td>interview &amp; CTS task</td>
<td>interview &amp; CTS task</td>
<td>interview &amp; CTS task</td>
</tr>
<tr>
<td>Final Interview with member check</td>
<td>June 16, 2006</td>
<td>May 1, 2006</td>
<td>May 16, 2006</td>
<td>May 12, 2006</td>
<td>May 26, 2006</td>
<td>Unavailable</td>
</tr>
</tbody>
</table>

In order for the data collection to be during the beginning of a new unit, some interviews and observations started after beginning secondary science teachers spent the first semester with their new students.
APPENDIX H
CTS AND OTS STUDY CODE BOOK

Codebook Key for Codes and Themes Developed from Interviews of Participants

Participant Key:
A: Alex
C: Cristina
G: George
I: Isobel
M: Meredith
P: Patrick

Key for codes of global, organizing, basic themes and codes:
Global theme:
  organizing theme
    basic theme
code: participant code
Themes and Codes Found in Data

Context:
administration
class visits: A
coming down from state: A
corrective criticism: A
class visits: A
I try to ignore him: A
principal: A
formal lesson plans: A & I

assessment
class participation: A & C
essay: G & I
feelings on medical advances: I
hurricanes: G
formative
catch it before it is ingrained: M
check whether they’re doing it correctly: M
crossword puzzle: P
discussion, greater sense of learning: P
exit tickets: I
homework: all
questioning: A, M & P
review: P
worksheets: all
grades: all
do homework, grades show it: I
everything else 50%: P
failing, absent for test: A
grade everything: P
hard to get A, easy to get C: P
have to have: M
homework 10%: P
lab 20%: P
not give C or D to get out of here: A
on the curve: G
labs: A
special needs: carrying B and C: A
test 50%: P
high-stakes testing: A, I, M & P
be able to do well: A
chemistry too late: I
have some standard: A
kids can’t stand: A
reading weakness: A
test strategy: M

Context:

assessment
homework: P
feasible to get higher grade: P
lab
activity: A, C
on information: P
reports: I
performance
dissection: P
don’t do: C
presentation: G
school doesn’t like: G
pop quiz
confirm my assessment: M
keeps them on their toes: G
management tool: G
mini-assessment evaluation: M
open notes: G & M
projects: A, C, M, & P
compost pile: A
extra credit: P
mitosis: M & P
model of cell: C
one every nine weeks: A
questioning: M & P
verbal banter: P
quizzes: I & P
student-made: I
tests: all
assess learning: A
best way: A
better idea what they grasp: A
depends on how much they retain: P
did not pay attention: A
did not read the question: A
dissection questions: C
dissection questions:
end of unit check: M
everybody does: A
grades pretty low: A
immediately associate with assessment: M
ingrained in my head: M
I was horrible at standardized testing: P
missing giveaways tough: C
mix up the formats: G
more than just a test: A

Context:

assessment tests

need to know it I
not open book: P
one way: A
on information covered: P
other teachers did not think tough: A
multiple choice/true-false/match.: G
some kids can’t take test: P
strategies

note-taking: P
studying: I
test analysis: A
tried and true method of learning: P

background:

segregated schools: desegregation: A

curriculum

added geologic scale: G
anatomy and physiology

inappropriate for HS: I
completely rearrange how I do everything: M
concepts: all

anatomy and physiology: I & P
general overview: I
muscles: P
root words and body orientations: P
review: P
systems: P

biology: A, C & M

aligned for next year: A
animals/evolution/classification: C
big unit on genetics: C & M
cell cycle: M
evolution talk: C
hitting the cells: A
just the basics: A
labs and experiments: A

chemistry: I
stoichiometry: I
what we’ve covered: I

cover all material: P

earth science: G
8th grade science: M

Context:
curriculum

- general science practices: G
- integrated science
  - basic knowledge: A
  - understanding: I
  - need to know applications: I
- hands-on: A
- high stakes testing: A, I & M
- resource books: A & G
- science requirements: A & I
  - biology next: A
  - need 2nd science: A
  - three years of it to graduate: I
- sequencing instruction: A & P
  - Newton’s laws: A
- skills: A & P
  - microscope: A
  - preparing slides: A
  - PowerPoints and technology: P
- standards: A, I & M
  - change next year to align with state: M
  - county and state: A
  - coverage: A
  - do they learn better: A
  - don’t agree with all of them: I
  - just paperwork: A
  - state requirements: A, I & M
    - reading: A
  - tie everything together: I
  - using another county’s as pattern: M
- technology: I, M & P
  - and science: M
  - for dangerous reactions: I
  - web site: P
- text: all
  - broke up into smaller sections: C
  - chemistry one not as bad as others: I
  - college level text
    - use as reference: I
  - cover all the areas in the book: C
  - doesn’t go into depth: P
  - don’t really care for how set up: M
  - don’t teach without: C
  - have to skip around: A
Context:

curriculum
text: all

how book broke it apart: P
junior textbook: M
like the one we’ve got: M
new text: A, I, M & P
  adopting new next year: I
  looking into books for next year: A
extra resources: M
good and bad: A
change isn’t always bad: A
like new books myself: A
more applied: P
prepare over summer: A
not following the book order: I
satisfied with book itself: P
6-7 books that go with it: A
stuck in the middle on using book: M
teacher’s edition: terms to cover: A
too much detail: C
use as guide: G
watered down from regular version: P
wish they had more activities: C
using what they used last year: G

education

BA environmental science: G
BS biology: A
BS biology: specialization marine science: C
BS biology/earth science education: M
BS ecology: I
BS marine biology: I
BS sports medicine: P
lab technician training certificate: A
MS Public and Environmental Affairs: I
teacher education program: M
teacher education coursework: intro: P
teacher education coursework: G

experience

college:
  first group to use cell microscope: C
  internship: cardiac rehab: P
  internship: water management: I
  research experiment: M
Context:
education
college:
    studied sperm whales: C
    work study with plasmobiologist: I
grant: fertilizers and water quality: C
non-teaching:
    Asst. Director for Club Sports: several years: P
    business: I
    computers: I
    Head Dir. for Outdoor Education: several years: P
    hospital lab tech five years: A
    medical home care market 25-30 years: A
    research assistant six months: C & G
    strength coach: one year: P
teaching: M & P
    exercise science classes: P
    internship: anatomy & physiology/biology: M
    elementary school science: P
    physical education classes: P
    substitute teacher: M
    undergraduate weight lifting: P
mentors
college professor: C & P
    geology: C
    advisor: P
        meticulous: P
        passionate about subject: P
    mentored swimmers: P
current school: A & I
    alternative certification: A & I
    English teacher: A
    integrated science teacher: A
    physics teacher: A
    teachers like a big family: A
football coach: G
high school teacher: A, G, I, M, & P
    algebra: story problems: I
    anatomy and physiology: M
    chemistry: old-school: I
    English: A
    history and coach: G
    9th grade science: A
Context:
mentors
high school teacher: A, G, I, M, & P
science: M & P
lecturer: M
tough but fair: P
middle school teacher: A
8th grade science: A
Mom: C
Context:
teaching route
alternative certification: A, C, G, I & P
catechism courses: C
certified w/in 2 years: C
certified w/in 2 years: G
coursework: A & I
passed subject exams: P
private school
Catholic school: C
non-sectarian: G
proficiency exams: A, C, G & I
state 3-year program: A & I
take three courses: G
always enjoyed science: G
could make a difference: A
entered biology/earth science education program: M
fisheries and marine mammal observer: C
found my people skills: I
frustrated with profession: A
got tired of computers: I
have the degree: A
knew going the teaching route: P
lost funding for graduate school: C
loved science: M
natural subject for me to teach: G
no personal satisfaction: C
planned on getting master’s first: P
planning to go to graduate school: C
sister suggested I teach in Catholic school: C
so unbelievably happy with teaching: C
started substitute teaching & loved it: M
teaching never a plan of mine: C
teaching only thing open: P
they need teachers bad: P
told I should be a teacher: A
went back to school: I
Context:

- **teacher**
- **assignment**
  - anatomy and physiology: I & P
  - get six next year: P
  - biology: A, C & M
  - 8th grade comprehensive science: M
  - environmental science: I
  - honors biology: M
  - honors chemistry: I
  - integrated science: A
    - five classes: A
  - marine science: C
    - one course: C
  - option teacher: I
  - 7th grade earth science: G
  - vertebrate biology: G

**issues**

- assessment: M
  - never enough time to go over tests: M
- budget: P
- class management: C & P
  - boys act better with girls: P
  - classes pretty much bipolar: C
  - girl who just knew everything: C
  - groups that are clique-y: P
  - separate right off: P
  - third period is a bit rowdier: C
- equipment: A, G, I, M & P
  - bunsen burners: I
  - computer acting up: G
  - LCD projector broken: G
  - microscopes: A
  - technology: M & P
    - pointer: M
    - availability: P
- facilities: A & P
  - benches instead of desks: P
  - get rid of carpet: P
  - need lab room: A
- materials: A, M, G, I & P
  - limited visuals: A
  - quality: P
  - supply closet
    - can’t find stuff: G
Context:

teacher

issues

materials: A, M, G, I & P
to touch: I
teacher education: M
real perspective: M
parents: M
time mgmt: M
discipline: M
really easy: M
same grade with half the work: M
some gave helpful info: M
too much theory: M
textbooks: A
not enough: A
time: A, C & P
lesson planning: A
lesson planning
also a tutor: C
just barely keeping my head above water: C
pay: C
doesn’t give enough money: C

Goals:

academic preparation: P
note taking: P
reach my expectations: P
using technology: P
careers in science: A, G, M & P
get to college-level science: A
how were computers invented?: A
knowledge to decide: A
something they want to pursue: A
tips on college: G

excitement for science C & M
engaged in lesson: C
get them excited about material: C
how things around them work: G
my teachers did that for me: M
not going to learn the basics: C
science can be fun: C
think of things scientific: C
ultimate goal: C
Goals

excitement for science C & M
what else can I take?: M
what you’re made of/how stuff happens: M

functioning in society: G & M
cheating is wrong: G

help the kids: A & G
through science: A
I want them to do well: G
I want them to learn: A
I want them to behave: A
I want them to think: G
not here to destroy their GPA: G

life skills; G, I & P
get them interested in school: G
need to learn to work together: I
public speaking: G
only one or two will play sports in college: G

pass test: A & M
every student make 100: A
high-stakes
do as well as possible: A
prepared for the test: M
test strategies: M
required science: A

quit being afraid: I
to ask questions: I
of grade: I
of not getting it: I
of science: I

relate to real-world: A
interdisciplinary: A
modern terminology: A

science skills: A, I, M & P
dissection: P
familiar with different types of equipment: I
learn to use microscope: A
prepare slides: A
problem solving: M
Goals

science skills: A, I, M & P
  seeing things in the lab: I

science literacy: M, I & P
  become more open-minded: M
  read articles actively: I
  basic understanding: I

science to take next: A
  better adapted for biology/chemistry/physics: A
  two sciences for college: A
  get it out of the way: A

shoot for an A: A & G
  average best of worst: G
  celebrate success: A
  give 100%: A
  mediocrity is not ok: A
  put their best effort into it: G
  start shooting for C go lower: A

understanding content: all
  a good base: A, G & P
  application: P
  have to stumble: I
  knowledge: P
  literacy: G & M
  figure it out on their own: I
  observe it on their own: I
  relate it to them: C
  science concepts: A
  terminology: C & P
  visualization: C & P
  when experiment worked: I

write research paper: C
  find topic they like: C
  learn how to use databases: C

Lesson planning

activities: P
  crossword puzzle: P
  worksheets: P

basic concepts: G & I
Lesson planning
  borrowed ideas/ materials: A & M
    they don’t mind: A
    very giving: A

content: P
  muscle movement: P
  terms: P
  diagrams
    coincide notes with: P
    hone in on: P
  experience with earthquakes: G

extra day: G & I

formal lesson plan: A & I
  required components: A
  school requirement: A
  standards included: A
  turn in after teaching: A

ideas: I & M
  brain decided let’s do this: M
  modified for available materials: M
  saw it on a video: I

labs: I
  acid-base reactions: I
  bending glass: I
  fitting them in: I
  making some goo: I
  outside: I
  precipitations: I
  shooting off rocket: I

materials: A, C, G & P
  making models: A
  making transparencies: A
  no time to order: C
  purchased labs: C
  only enough for pairs: C
  not able to plan: G
  two different note styles: P

notes: C, G & P
  give them all the same things: G
Lesson planning
Notes: C, G & P
  using college notes and textbook: P

pacing: P

project: A & P
  muscles map: P

real-world: A & P
  ‘at the clinic’ aspect: P
  links: A

rough idea of lesson: I

sequencing information: M

simplify concepts: C

skills development, standards, summary: A

supplements: all
  add extra material: C
  activities book: A
  college text: C
  companion texts: A
  internet: C, G, M & P
    on-line lesson plans: C
    outside resources: C
    web site: M
  new edition materials: M
  technology: I & P
    PowerPoints: P
    using media: I & P

textbook: all
  key facts and ideas: P
  starting point: C & P
  highlight important parts: A
    read: A
  skim through section: G
  students allowed to use: P
  things not in it: G

time: A, C, G & P
  not able to plan: G
Lesson planning

time: A, C, G & P
  schedule’s just crazy: C
  spent multiple hours: A
  want to do versus have to do: P

visual aids: A & P
  hone in on: P

Science

concepts
  atoms: G
  biology: C, I & M
    difference between stingray and skate: I
    differences in meiosis and mitosis: M
    DNA & genetics: C & M
  cells: A
    animal and plant: A
    cork: A

Science

concepts
  chemistry: I
    basic building blocks of life: I
    not magic: I
  environmental science: I
    lack of student knowledge: I
  geology: A & G
    erogeny: G
    learning about tides: A
  how muscle works: P
  lactic acid: P
  no right answer in science: C
  physics: A
    nothing but momentum and stopping speed: A
    trajectory shoot above him: A
  use science talk: C

nature of science: G & M
  belief-systems: M
  evolution: M
  misconceptions: G

scientific method: I
  observation methods: I
  use all the time: I
Student ability: all

best class at beginning of day: C
biology has no special needs students: A
bright kids: P
bright spots all over: I
cluster of kids know everything: C
don’t understand evolution and classification: C
fairly bright in the subject: A
get more accomplished second period: C
grades: A

g got through to these students: A
hard to get the median: A
low C to high D: A
grouping: P
best student does all the work: P
worst student does none of the work: P
low to high; A & I
changed from 20 years ago: A
low performers do well: I
tough teaching the whole gamut: A
math, guys like or have taken more: I
mixed class: P
second period a nice little mix: C
slow things down a bit: C
smart and not so smart: G
some don’t have a clue: C
some get it more than others: G
some need more work: G
some really struggle: P
some super high achievers: C
special needs: A, C, I & G

a lot of kids have pretty bad ADD: C
across the board: G
age-related thing: G
already use it as a crutch: G
better at some areas: G
couldn’t remember what it was called: C
ESOL: I
family with medical problems: I
gifted: A
have that connection: C
individual plans: C
kids below the 25%: C
learning disability: A
learning problems: put in front row: C
Student

ability: all
special needs
  math skills: I
  physical disability: A
  reading ability: A & I
  third period a bit lower: C
  which ones know the answers: A

developmental level: C & G
  can’t take notes & pay attention together: C
  focused on their grades: G
  girls better students: G
  have their roles: G

difficulties: G, I & M
  cheating, copy others: M
  don’t make connections right away: G
  fear of subject
  chemistry too hard: I
  inexperience w/experiments/equipment: I
  writing things down: I

discipline: A
  difficult to get them to raise their hand: A
  holler answers out anyway: A
  talking, just let him talk: A

interest/motivation: all
absences: A
active involvement in lesson: A & C
alertness: C & I
  attention hard to get: C
  first period, kids dead: C
  is this the right answer?: C
  second period best, awake, not weary: C
  some good some bad: I

all searching animals: C
ambivalent towards schoolwork: I
annoyed @ one person answering questions: C
as a group they’re goofy: M
better at doing their homework: G
bright spots: I
call on those not paying attention: C
can’t afford to feed them all the time: M
can’t believe using college material: C
Student

interest/motivation: all
chose to be in biology: A
classes different: G
colors, some classes liked different: G
comfort level
  come in to chit-chat: I
  low in chemistry: I
completing work: A
copying: G & M
definitely been on top: M
dissect the animals: C
don’t like carrying books: P
don’t like do things on own: I
don’t listen: M
don’t stay on task: G
don’t want to do homework: G & P
excited about animals: C
excited about figuring out for themselves: C
get interested: P
good interest in the subject: A
got excited about this: I
grades: A
  intervention story: A
hadn’t even set up the lab: M
hard time staying focused: M
have to use your brain: M
individual attitude or aptitude: A
just marking time: A
lack of effort: G & I
lackadaisical attitude: G
let upper-level kids answer questions: C
never do the reading: G
on task: A
overall they try: P
really focused: C
repeated the class: A
rough classes: A
some bored: P
some only here for third-year science: I
start off with positive attitude: C
success story: I
talking about weightlifting and lactic acid: C
their responsibility: M
they’re hilarious but...: M
think I should tell them [answers]: I
Student

interest/motivation: all
took to see animals: C
want to learn the animals: C
wants to learn: A
watching videos on animals: C
when will I ever use this?: A
willingness to learn something new: C

learning

aids: C
air pressure: I
bunch of particles bouncing around: I
did a demo: I
started asking questions: I
barriers: A & G
groups: A & G
political correctness: A
building confidence: I
class dynamics: I
comprehension: all
all bombed the test: C
basic knowledge: A
bright spot: I
can’t expect them to know it: I
confusion with meiosis and mitosis: M
cumulative: A
did not have a clue: I
did not understand material, no active teaching: C
don’t think it stuck: M
everybody probably understands it: C
failing students: A
go back and troubleshoot: I
got through material: G
grasping the basics: A
in the back of their head: I
kids thought test hard, teacher easy: C
lack of background knowledge: I
lesson never clicked with kids: C
made them think: A
math skills weren’t up to the level: G
marginal student: A
may have recognized more terms: G
most of the time they will know the answer: C
need to experience it: I
need to function on a higher level: G
Student learning

- comprehension: all
  - one struggling more than others: G
  - pretty consistent: G
  - retention: C & G
    - not going to remember in ten years: C
  - slower students
    - slow down class: A
  - some always clueless: M
  - some are guessing: A
  - they’re getting it: P
  - think they’ve learned: G
  - think everybody understood for most part: C
  - understand material for their ability: C
  - wasn’t sticking: P
  - able to recognize it: M
  - actively understanding: C
  - be able to work backwards: C
  - did it very slowly: C
  - do something with it: C
  - great job with Punnett Squares: C
  - let them see what they know: C
  - made predictions: M
  - makes sense: I
  - pulling it together: I
  - started to connect the dots: G
  - what happens if?: C

- engagement: A, C, I, G & M
  - active involvement: C
  - full attention: C
  - good about volunteering: M
  - good interest in the subject: A
  - hands-on experience: M
  - interest: G
  - internet: G

  - labs: A & I
    - reports: I
      - focus on observations and methods: I
      - force them to think about and write down: I
  - real-world: C
    - lactic acid buildup
      - excited about it: C
      - shared with friends: C
Student learning

engagement: A, C, I, G & M

seating plan
separate discipline kids: C
shouting out answers: M
making connections: C, G, I & M

prior knowledge
agricultural science last year: A
broken bone become expert: P
know muscles: P
remember from last year: C

reading book
pick out information: I
remember reading it: I

scientific method: I

skills, never seen microscope before: A

styles
asking questions: A
demos: I
groups: A & I
good old boy network: I
guys want to communicate: I
girls more timid: I
migrating: A

hands-on: M

labs: I
partners willing to take risk first: I
switch back and forth: I
really like: C

notes: A, C, G & M
blindly writing down what’s on overhead: C
don’t respond to notes: M
have to take so many: A
just shut down: C
learn better by writing down: A
memorize for test: G
nobody likes diagrams on PPT: P

multiple intelligences: M & P
tried a lot of different things: M

pacing: I
questioning: C
could tell they were lost: C
too long wait time embarrasses kids: C

reading: A, I & M
group reading: A
Student learning
reading: A, I, G & M
procedure, poor at reading: M
using book: I
tailored questions: I
prefer testing: G
visual: C, G, I & M
do problems in their heads: C
can see it in my head: C
helpful for them: G
kids that need it: C
I’m a visual person: C & G
technology: M & P
warm-ups: M
synthesize articles: I
visualization: M
teacher-student interaction
paying attention: C
when they stop asking: C
when they actually have to do it on paper: I

maturity level
middle school kids: G
learning will eventually be important: G
preparation: M
persistence: C
don’t give up easily: C
like my teaching: C
they want to know: C
retention poor: M
socialization
let them pick their own groups: M
gravitate towards small groups: M

Teacher characteristics
able to teach at different cognitive/age levels: I & G
aptitude: G
background knowledge: C
enthusiasms: A
experience: P
formal training: P
interest in teaching: G
knowledgeable: I
Teacher

characteristics
   personality & attitude: C
   skills: I

learning styles
   hands-on: A, G & M
   horrible at standardized testing: P
   lecture; C & M
   note-taking: C & M
   warm-ups: M

Teaching

block periods: A

can’t teach a lot of math: G

catch it before it is ingrained: M

chemistry is not magic: I
   basic understanding: I

don’t memorize, understand: I

discussing issues: A

feelings: A
   can get repetitive when teaching same classes: G
   get better as the day goes on: A
   love to do more classic earth/space science: A
   rough day: A
   some days better than others: G

generating excitement
   as enthusiastic as I can: C
   kids thought I was crazy: C
   taking things and throwing it in: C

get some other teacher’s children: A

grouping
   working on getting better: A

making connections
   hands-on: C
   I thought it was good: C
Teaching

making connections
look at information in different ways: M
tried to link what they know with learning: C
warm-ups for understanding: M
what am I doing?: C
what’s happening with the ball?: C

more information than you know: I
pedagogical knowledge: A
proximity: P

questions
need to get away from group questioning: A

reasoning skills: I

retaining students: A

seventh grade
not particularly impressed with them

student questions, never have problem with that: A

Teaching:
strategies
activities: all
brought in hands-on: C
compare and contrast: I
definitions on transparency: A
diagrams: very slowly work through it: C
homework: A
internet: C
just means hands-on: C
lab aids on evolution and classification: C
lab data sheet: I
large charts/small models: P
let them see it & touch it: C
NSTA selective permeability: C
problem calculations: I
Venn diagram: M
warm-up: M
worksheets: A, C, G & P

cognitive levels: C & G
approaching material differently: G
Teaching:
strategies

cognitive levels: C & G
background first: G
find out what they know: G
keep them all around the same area: G

classroom management
fine line: G
little bit of leeway: G
seating plan: C
discipline: C
shock them with hard stuff: C
strict with rowdier kids: G
verbal discipline: C
demonstrations: A, C, G, I & P
aluminum cans: I
always little things: G
balloons: I
help them visualize better: G
models: A
perked up: G
science skills: C
transparencies: A
debate
planning on it: G
diagrams/drawing: G & I
discussion: C & I
way to help rope them in: C
encouragement: M
essay, worked out well: G
focal space: P
groups: all
ability: P
assigned: P
groups: all
can’t do everything on your own: I
class rules: P
gender: P
group work: M
hands-on: M
learn to work together: I
pick their own partners: I
Teaching:
strategies
groups
size: C, G & P
  big more out of control: C
  pairs with my upper school class: G
  small for collaboration/materials: C
  sometimes half the class: G
  try to keep under three: G
hands-on: A, C, G, M
  able to show [projects] to other classes: M
  always more things possible: G
  get them out of their seats: A
  like to do the hands-on: A
high interest topics
  field trip to see animals: C
  organismal side: C
  videos: C
jokes, kept them more interested: G
labs: A, G, I & P
  do it twice: I
  doing it wrong teaches you: I
  one per chapter: G
  see what they’re seeing: A
  try some kind of experiment: A
  write what they observe: A
lecture: C, G, P
  don’t know another way to teach: C
  to a point where we can discuss: G
  link concepts: G
note taking: C, G & P – M found did not work
  advanced organizers: P
  a little bit of a groan: C
  don’t know another way to teach: C
  don’t respond near as well as I did: M
  impossible not to take notes: C
  get concrete definition down: C
  give fill-in-the-blank notes: C & G
    become dependent: G
    more uniform: G
    not every time: G
  just give them a bunch: G
  kind of facts and facts: C
  lots of in-class assignments: C
  notes on everything: C
  teacher’s saving grace: C

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Teaching:

strategies

outside activities
organism surveys: C
hands-on stuff: C
overview: I
pacing: P
peer teaching: A
pop quiz: G & M
projects: A, G, M & P
cell division: M
every nine weeks: A
planets: G
questioning: C, G, M & P
breaks it up: G
call on people who aren’t participating: C
can’t say I don’t know: C
collectively answering question: M
compare and contrast: M
don’t let sit for long period of time: C
don’t move on to next person: G
encourage when they get half right: C
excited when figuring out for selves: C
fish for questions with them: C
how much they knew: I
keep on asking them vice sitting there: C
keep them involved: G
lead them to their own conclusion: I
randomly call on them: C
students somewhat interested in things: G
real-world: G
reading: M
review: A, C, G, M
as we go: G
bring them back with a little: G
chapter: A
go over what we did the day before: C
often key terms: C
preview before task: M
students teaching chapter: A
students work with own strategies: M
teaching special needs kids: G
technology: G, I, M & P
PowerPoint and LCD projector: G & I
video: P
web sites: G & M
Teaching:
strategies
technology: G, I, M & P
web sites: G & M
for ideas: M
virtual lab: M
textbooks: C & P
couldn’t teach without: C
visual, students come up with: M
write questions: A

style
anything they can see: A
authority: P
break it down into sections: A
build up to the hands-on: A
discussion: P
enthusiastic: I & M
excited: I
silly movements: I
everyone makes mistakes: I
flexible: I
general questions: A
get through the nuts and bolts: G
know what you’re talking about: G
hands-on: A
informal: G, I & M
mess around with them: G
not traditional: G
sit down and chit-chat: I
teacher-student interaction: P
very open: I
walk around the room: I
young, step away from their age: G
kind of lecture: I
lecture: C & P
management and teaching together: G
modeling: M
multiple strategies: M
process-oriented: I
proximity: M & P
questioning as focus: G
put it in the modern-day world: A
small to big: P
start off basic: I
student responsibility: I & M
Teaching:

style
tailor the information: P
teacher-student interaction: I & P
technology: C, G, I, M & P
telling stories: G & I
tracings: A
write it down: A
visual: A & G
  better with pictures: G
  present different ways: G
  use visuals: A
wait time: C
  long when posed to whole class: C
  they can find that right answer: C

want to see students succeed: A

what do I need this for?: A

write it down: I
LIST OF REFERENCES


BIOGRAPHICAL SKETCH

Dina L. Mayne was born in Des Moines, Iowa, to Yvonne and Frank Mueller. She graduated from Wichita State University with a bachelor’s degree in secondary science education and a master’s degree in curriculum and instruction with an emphasis on science education and educational technology.

Dina taught chemistry, physical science, and integrated science for seven years as well as two years of computer programming in high schools in Kansas and Florida prior to starting her Ph.D. For two years she taught science methods to undergraduate pre-service elementary teachers and has done research in the areas of elementary education, science education, educational technology and peer mentoring.

Dina, her husband, daughters and granddaughter reside in Georgia. She is currently teaching chemistry and physical science at the high school level.