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KNOWLEDGE, BELIEFS, & PERFORMANCE OF NEW HIGH SCHOOL CHEMISTRY TEACHERS: A STUDY OF TEACHERS' CHARACTERISTICS & TEACHER PREPARATION PROGRAM INFLUENCES

By

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A DISSERTATION

Submitted to
Michigan Sate University
In partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Teacher Education

1998

ABSTRACT

KNOWLEDGE, BELIEFS, & PERFORMANCE OF NEW HIGH SCHOOL CHEMISTRY TEACHERS: A STUDY OF TEACHERS' CHARACTERISTICS & TEACHER PREPARATION PROGRAM INFLUENCES

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This study investigated the influence of teachers' characteristics and secondary science teacher preparation programs on new high school chemistry teachers' knowledge, beliefs, and performance. "New high school chemistry teacher" refers to any teacher who during their first three years of teaching, has a major/minor in chemistry and/or any teacher who teaches chemistry for high school students. This research focused on four new high school chemistry teachers in their second year of teaching who were part of the Salish I Research Project. These four teachers graduated from two different teacher preparation programs, at major research universities.

The focus of this study was on teachers who demonstrated one or more of the following teaching styles: teacher-centered, conceptual, and student-centered. A cross case analysis was done among these four teachers to explore the linkages among teachers' characteristics, secondary science teacher preparation program features, and new high school chemistry teachers' knowledge, beliefs, and performance. Data included interviews with university faculty in education and in science, analysis of course syllabi and program

descriptions, interviews with the new teachers, analysis video portfolios of the classroom teaching, and other data collected as part of the Salish I Project.

The key findings of the in-depth study included: 1) The course objectives in the teacher education courses at both institutions were more diverse and more comprehensive than science disciplinary course objectives. 2) All four of the new teachers and most of the faculty interviewed confirmed that the connections between prospective science teachers' learning and real world applications were not clearly addressed as a major goal in science courses at either institution. 3) Prospective science teachers did not experience cooperative learning in their science courses, but did so in education courses. 4) All new secondary science teachers reported that they experienced a much wider variety of assessment methods in their science education courses than in their science courses. 5) All four of the new teachers identified that learning from on-the-job experience or field experience in their teacher preparation programs was crucial in developing their teaching approaches. 6) While all four of the secondary science teachers hold student-centered beliefs about teaching, only one consistently demonstrated student-centered teaching. 7) Evidence from video portfolios showed that the new secondary science teachers did not reflect a deep conceptual understanding of the scientific concepts that they taught, even though the content of the lessons was from their minor scientific field.

More empirical research is needed to explore the influences of teacher preparation program features on prospective science teachers' performance in more than one year of teaching, and when they are teaching in their major field of study.

DEDICATION

"In the name of Allah, Most Gracious, Most Merciful"

First of all I would like to thank and pray to my almighty Allah (God) who has supported me with faith, patience, and energy to achieve one of the most important goals I have ever achieved. This dissertation is a reward to the important people in my life whose spiritual, love, and continuous support have made this dream become a reality: to a very special women in my life, my wife Manal for her unlimited support and diligence during this journey; to my lovely children Adalia and Ghayth for giving me the hope to work very hard to be a good father; to my brother Adnan who has dedicated his life to his family; to my parents who made a lot of sacrifices to provide their children with every opportunity to be prosperous; to my parents-in-law for their being patient with not seeing their daughter for five years and more; and finally, to my brothers, sisters-in-law, and brothers-in-law for being proud of Qasim's success and providing me with motivation.

ACKNOWLEDGMENTS

"In the name of Allah, Most Gracious, Most Merciful"

"Praise be to Allah The Cherisher and Sustainer of the Worlds"

I would like to extend my appreciation and gratitude to my academic advisor and dissertation director, Dr. James Gallagher. His support, encouragement, and guidance through my Ph.D. program at Michigan State University were helpful for me to achieve one of the most important goals in my life.

In addition to Jim, I am also deeply indebted to Dr. Deborah Smith, Dr. Edward Smith, Dr. Joyce Parker, and Dr. Paul Hunter for their consistent support and encouragement through my stay at Michigan State University, and their written feedback and conversations about my work.

I am very thankful for my best friend Don Duggan-Haas. Don played a significant role in helping me achieve my goal. He sacrificed his personal time to edit, read, and discuss issues with me in order to finalize my dissertation. We have worked closely together over three and a half years on the Salish Project. We analyzed videotapes and interviews together, participated in intense meetings and conference calls with Salish researchers from around the United States and around the world, and presented papers together at various professional meetings. I also wish to express my thanks for Katy Duggan-Haas for her support of both Don and me as we worked through the Salish Project.

Finally, very special thanks to the four teachers who agreed to allow me to use their data and write case studies for the purpose of this dissertation.

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CHAPTER 1

INTRODUCTION

This chapter provides a discussion of the nature of the problem followed by the research questions, a review of the relevant literature, and description of the purpose of the study. The chapter ends with an overview of the dissertation itself.

The Problem

A woman is observed standing in front of a group of teenagers[1] with a variety of body types and facial features, in a modern looking building in a small American city. She is talking to the teenagers and writing a series of numbers and letters on a green board. Occasionally, we hear the woman ask questions to a few of the teenagers. Some of them must have given appropriate answers because we hear the woman giving them affirmations. If we take a look around the room we observe some teenagers with their eyes closed and mouths open, some are reading books inside books, we see some frantically paging through their books as if looking for something important, and some are just listlessly sitting looking at the woman with numbed stares. Not knowing what was going on in the room, you stop someone walking by and ask them what is going on in the room. The person responds by telling you that the woman is a teacher and that she is

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[1] This imaginary story was part of a paper presented by Alshannag, Bailey, Cheng, Dodge, & Malakolunthu in TE921 class "Learning to teach" at Michigan State University as one of the course requirements.

teaching the teenagers about chemistry and that the teenagers are students who are learning from the teacher.

In this hypothetical situation the assumptions of the passerby are very broad and revealing about what takes place in today's classrooms (or what is assumed to take place in today's classrooms). The passerby assumed that the woman standing in front of the class was helping the students learn chemistry. She appeared to know the language and symbols used in the discipline of chemistry and was telling the students about the knowledge she had. The students were assumed to be taking in all of this information and finding the information valuable. We may laugh at these assumptions about what was taking place in the classroom, but these ideas are not so uncommon. They mirror what many people believe is occurring in classrooms all over the world.

This hypothetical case could raise many questions concerning teachers' preparation and their teaching. Someone could ask, why is she considered to be a teacher? Is it because she knows more about chemistry than her students? Is it because she knows how to present knowledge to teenagers? Is it because she knows what ideas in chemistry are difficult for her students to understand and knows how to address these issues so that the students understand them? Is it because she knows her students' backgrounds? A lot of questions can come up that highlight issues related with teacher's knowledge, beliefs, and practice.

Generally speaking, the learning of chemistry, as well as science more generally, is seen by most students as irrelevant to their lives and to the world around them (Cajas, 1998; Linn, et. al, 1997). Furthermore, Gallagher (1991) indicated that, "the academic community has virtually no vehicle for helping secondary science teachers learn about the applications of scientific knowledge in the daily lives of their students" (P.128). Yet, making connections among chemical concepts, natural phenomena, and the real world is essential for any learner to understand these concepts (Tobias, 1992).

The macro level of connections was also mentioned by Gräber (1996). He argued that the importance of chemistry for the environment, for everyday life and for sociopolitical relevant problems must be emphasized in classroom instruction.

In common practice, Tobias (1992) found that teaching chemistry is highly focused on content. Chemistry is generally taught as clusters of isolated concepts, formulas, chemical and mathematical equations, and theories (American Chemical Society, 1990; Kirk & Layman, 1996). This is true in the teaching of chemistry at different levels: middle school, high school, and college. Prospective high school chemistry teachers as well as other science disciplines teachers almost always enroll in their introductory science courses through Colleges of Art and Science with students who are traditional non-teaching science majors (Salish, 1997).

The prospective secondary science teachers will learn more about scientific knowledge and less about the process of science because of the nature of these courses (Gallagher, 1991). This way of teaching science at the undergraduate level likely influences these teachers' knowledge, beliefs, and practices as they move into their own classrooms.

Furthermore, these prospective teachers, when they complete their science courses, would not understand fundamental concepts in a way that would allow them to teach these concepts effectively. For example, Lee & Magnusson (1997) studied the college students' molecular-level representations of common chemical phenomena, including solution chemistry. They found that college students had gaps in their knowledge and a lack of development in their conceptions of solutions, even after several years of formal study in high school and college.

This lack of students' understanding at the college level will not be solved by taking more academic courses. Sanford (1988) confirmed that prospective science teachers do not acquire the content knowledge of any science discipline, and understand it for the purpose of teaching, by enrolling in these academic disciplinary courses. She says:

> "...there is a growing awareness that university study of an academic discipline may not provide the kind of knowledge and understanding that teachers need to effectively transform their academic knowledge into instructional activities in the classroom."

Sanford's argument was supported by Ruthann (Schulke, et. al, 1991), a new chemistry teacher who thought that if she took more undergraduate chemistry courses, it would properly prepare her for teaching, but she found that that was not the solution. She feels,

> "...[I] was required to take enough undergraduate chemistry courses to properly prepare me for teaching but *I lacked the opportunity to discuss the presentation of specific topics in chemistry.* I would have benefited from a course where each prospective teacher had to present a chapter and then discuss the problems they had with the material and its presentations" (Schulke, et. al, 1991. P.20). [emphasis added]

Ruthann's needs as a chemistry teacher raises questions about the nature and the effectiveness of teacher preparation programs from which prospective teachers will graduate. Those kinds of needs should motivate science educators and scientists to design courses that integrate the content and pedagogy for the purpose of teaching. As Shulman (1986, 1987) emphasized, teachers need to draw their transformations of a subject matter from diverse kinds of pedagogical content knowledge-- amalgams of subject matter and pedagogical knowledge.

An adequate base of pedagogical content knowledge could help chemistry teachers break down the abstract nature of chemistry. For example, atoms and molecules are much too small to be seen and difficult for students to conceptualize. The abstract nature of chemistry as a subject makes it difficult to plan and teach effectively, but if prospective chemistry teachers acquired pedagogical content (chemistry) knowledge through their teacher preparation programs, they would be more able to move these chemical concepts to a concrete level and their students would be more able to understand these concepts.

The weak connection between the lecture and the chemistry lab at the undergraduate or high school level does not generally help students understand chemical concepts. In general, chemistry instructors use demonstration activities or chemistry labs to confirm the scientific facts in chemistry textbooks, rather than as investigations of chemical concepts through inquiry activities. This inquiry orientation is believed to be more effective in helping students understand the scientific concepts (Erwin & Pestel, 1992, a & b). This was confirmed by (Linn, et. al, 1997). They found that chemistry laboratory typically is intended to illustrate facts and principles, but not to investigate these facts through inquiry activities.

The way in which chemistry is being taught led me to think about how we can promote students' understanding in chemistry, especially for prospective science teachers. Research results and my professional experience (see Appendix A) indicate that there are relationships among a chemistry teachers' background (i.e. the kind of science training that each teacher had), teacher education programs, a chemistry teachers' knowledge and beliefs, and the chemistry teachers' performance.

In this study, I explored several of these relationships in depth in order to gain a better understanding of what characteristics of teacher preparation programs are effective or not effective. The study is designed to answer the following research questions:

<u>The Research Questions</u>

1) What is the training of new high school chemistry teachers? In order to answer this question, the following sub questions need to be answered:

- a) What is the variety of subject matter background they experience during their pre-service education?
- b) What kind of courses did they take?
- c) What kind of chemistry training and experience did they have?
- d) What is their background in mathematics and physics?
- e) What is their pedagogical training in teacher education?

2) What are the features of the teacher preparation programs these teachers experienced?

3) What are their beliefs about the nature of science and teaching science?

4) What are the key features of the classroom performance of these new high school chemistry teachers?

5) What kind of preparation experience and knowledge contributes to a teacher-centered, conceptual, or a student-centered teacher?

A Review of literature

Educational reform is ideally seen as part of the social transformation of contemporary schooling (Popkewitz, 1988). There is an enduring faith placed in schools as an engine of social and individual improvement. Policy makers turn to schools as a tool when social problems emerge (Cuban, 1990 & 1995). Countries all over the world try to make changes and/or reforms to the educational systems in order to improve individuals and societies.

In United States, many waves of reform have been initiated in the last three decades. During the first wave of reforms in the 1960s & 1970s, curricula were updated and inquiry was added as an important focus of science programs. In the 1980s, the social consequences of science and technology became the focus through programs labeled science-technology-society (DeBoer, 1991). In the 1990s, reformers sought mainly to expand or improve educational inputs by increasing the length of the school day and year, increasing requirements for graduation, and recruiting better teachers. Also, efforts were made to insure students learned desired knowledge and skills through standardized graduation tests, specified curricula, and promotional criteria. It was during the decade of the 1990s that national standards were developed and promulgated in science and other fields. Other reformers in the middle to late 1980s called for fundamental rethinking and restructuring of the process of schooling (Ramsey, 1993; Smith & O'Day, 1990).

Specific reforms in education have targeted science education. Recently, in science education most of the partners are seeking systemic reform involving in science curricula, students' learning, teacher preparation and teacher education programs, teaching, student achievement, administrative leadership, and school policies (American Association for the Advancement of Science (AAAS): Benchmarks for Scientific Literacy, 1993; (AAAS): Blueprints for Reform, 1998; (AAAS): Science for All Americans, 1990; Anderson, et. al, 1994; Atwater, 1996; Floden, et. al, 1995; Goodlad, 1990: National Research Council (NRC), 1996; Ramsey, 1993; Smith & O'Day 1990).

Since the mid 1980s, science teachers' professional knowledge has been the focus of scholars. Many researchers call for the shift in the paradigm of teachers' knowledge from "dual nature", (i.e., the dichotomy between content and pedagogy) to the missing paradigm, "pedagogical content knowledge" (Shulman, 1986).

Gallagher (1993) described the historically dominant paradigm in secondary science teaching as transmitting information to students, learning as the acquiring of that information through memorization, and assessment as measurement of the students' achievement in acquiring that information for the purpose of giving grades. Many teacher education programs has been reorganized and structured to fit with a new theoretical orientation that focuses more toward academic conceptual orientation and practice in learning to teach (Feimen-Nemser, 1990; Holmes Group, 1990).

Recently, reform in science education has addressed many key issues that help educators make changes in the content of instruction. The main features of this reform movement is to focus more on the development of a student's conceptual understanding instead of on rote learning and the acquisition of facts and skills (see for example, AAAS: Science for All Americans, 1990).

Conceptual understanding in science means that the learners are able to use scientific knowledge to describe, explain, predict, and control the world around them. Anderson and Roth (1989) analyzed these components of scientific understanding focusing on the functions or uses of scientific knowledge. This includes activities (description, explanation, prediction, and control) in which successful learners of science are engaged. The other component focuses on the structure of scientific knowledge (conceptual frameworks) that science learners use to make the interconnections among scientific knowledge, other kinds of knowledge, and their own personal understanding of the world. The most significant part of their analysis was that scientific understanding requires extensive conceptual integration and an ability to work out the complex relationships between the structure and function of science.

This raises the question, what is important for a conceptual understanding in chemistry?, clearly, it is not to ask learners to memorize all of these chemical formulas, chemical reactions, chemical bonds, etc., but rather it is important to help learners acquire this kind of knowledge through their involvement in activities that allow them to use science process skills to develop valid, meaningful scientific understanding of these concepts.

Through the process of integration of structure and function of scientific knowledge, learners are part of a meaningful learning process. This process requires students to go through a very complex process of conceptual change in which their own ways of thinking and viewing the world must be challenged and tested in front of the scientific conceptual frameworks.

Research on students' learning science has indicated that learners hold different conceptual frameworks than scientists. Many empirical studies (for example, Driver, 1995; Pfundt & Duit, 1994; Wandersee, Mintes, and Novak, 1993) provide evidence that students hold pre-instructional conceptions in many fields and these are substantially different from the scientific concepts taught in school.

Learners' conceptual frameworks include many misconceptions and naive conceptions that are different from the experts' conceptual frameworks. The experts in various scientific domains hold well-structured conceptual frameworks or schemes that include knowledge about the usefulness of that knowledge in a variety of specific situations.

Several studies have shown that misconceptions are not just the domain of the students. Often times teachers, especially elementary teachers, (Smith & Neale, 1991) have misconceptions and naïve conceptions about the subject matter they teach (Ball & McDiarmid, 1989; Smith & Neale, 1991). The misconceptions held by teachers can blind them to student misconceptions and cause the teacher to develop inappropriate explanations resulting in the failure of teaching for understanding (Anderson & Smith, 1987; Smith & Neale, 1991).

However, Smith (1990) argued that, "learning science with understanding is desirable for all students." So, in order for students to understand science, Edward Smith proposed two criteria for understanding in science (i.e., for conceptual change): "connectedness" and "usefulness" of the scientific ideas in social contexts."

Teaching science for conceptual understanding requires a richer understanding of science than is held by most science teachers. One of the most important factors in teaching science for conceptual understanding is teachers' knowledge, and how they translate that knowledge into teaching practice. For example, data from the Salish I project (1993-1996) indicated that the practice (teaching) of new secondary science teachers in the United States tends to be more didactic, i.e. new teachers believe that knowledge is fixed and it is in the textbooks. Many research studies confirm that this kind of practice is widespread. (For example, see Gallagher, 1993).

Teaching science for conceptual understanding requires teachers to understand science concepts and to make connections between these concepts and its applications. Conversations I was involved in at the conference on Revitalizing Undergraduate Science and Mathematics Education, held at Michigan State University, May 8-10, 1997, indicated that even student teachers who majored in science lack understanding of important, fundamental science concepts. Even though they know many facts and laws in science, they do not have an integrated comprehension of them nor do they know how to apply them in everyday life. Their lack of understanding science certainly limits their teaching science effectively.

To teach science for conceptual understanding, teachers need to understand the nature and philosophy of science (Gallagher, 1991). Again, data from the Salish I project indicated the lack of understanding of the nature of science by new secondary science teachers. For example, many of them believed that scientific facts are always true. This kind of understanding (of the nature of science) is essential for science teachers in order to help their students understand the limitations and the nature of the scientific knowledge (Driver, et. al, 1996).

Teaching science for conceptual understanding requires teachers to transform the content knowledge using pedagogies that are sensitive to the students' ideas and conceptions, however as pedagogical content knowledge. Pedagogical content knowledge represents "that special amalgam of content and pedagogy that is uniquely the province of teachers" (Shulman, 1987, p. 8). It refers to knowledge of the ways of representing and formulating science topics that make them comprehensible to students. It includes an understanding of what makes the learning of a specific science topic easy or difficult, for example, the preconceptions and conceptions that learners bring to the topic.

So, in order to enforce a learner's understanding in chemistry at different levels, teachers need to be prepared to teach for conceptual understanding. To do so, teachers need to match their knowledge/beliefs with their practices. This means that if a teacher has a conceptual knowledge/beliefs, then we could expect that teacher to teach as a conceptual and/or a constructivist teacher. Clark and Peterson (1986) have pointed out that teachers' conceptions affect their planning and classroom decision, while conversely their teaching activities influence their conceptions. In addition to that, Briscoe (1991) suggested that to make changes in science teachers' practices, teachers must examine their beliefs, judgments, and thoughts regarding what they do and how they do it.

The discrepancy between teachers' knowledge/beliefs and their teaching practices influences the way in which teachers teach science. It follows that science teachers could deliver science instruction to the students as a body of knowledge without any connections to science processes or to students' lives in the real world. This conception of scientific knowledge does not match the conception of teaching for conceptual understanding (in which the integration between the structure and the function of science is necessary).

There are many factors that would influence teacher's knowledge and beliefs. One of them is related to the way they were taught science through K-college. If they were taught science in didactic and traditional ways, then they generally try to teach the same way (Ben-Peretz, 1995). Therefor, it is widely believed that teachers often teach the way they have been taught. Subject and teacher education majors have had extensive experiences as students in college and pre-college classrooms, which has a strong impact on how they will organize and teach a course in their subject matter (Ball & McDiarmid, 1989; Ball & Wilson, 1990; Grossman, 1990, Gohlke, 1995). Consequently, a major challenge will be how to change the very deeply enculturated ideas that teachers have about scientific knowledge.

Teaching for conceptual understanding requires teachers to know both substantive and syntactical structure of the scientific discipline (Schwab, 1978; Bruner, 1986). Knowing the structure of the discipline is important in order to make a connection between structure and functions of science. This kind of knowledge would help science teachers in constructing their PCK. In other words, knowing the structure of a discipline might help teachers to transfer science concepts to their students in a meaningful way, and allow the teacher to use many metaphors, models, examples, and ideas to facilitate the students' understanding (Wilson, & et. al., 1987). However, Deng (1997) found that knowing the structure of the discipline of physics does not guarantee that physics teacher has the specific kind of subject matter knowledge needed for teaching school physics. Further, Dong found that the subject matter taught in college level physics was substantially different from that taught in high school physics, as a result, college physics did not provide background in important topics- the high school program.

What teachers need to know is more than personal understanding of the subject matter they are expected to teach. It is clear for most scholars that teachers need to know more than subject matter. They need to know something about theories in educational psychology, teaching methods, the philosophical and social foundation of education, students, curricula, and school context. However, it is very clear that teachers' subject matter knowledge plays a crucial role in teachers' professional knowledge.

Subject matter knowledge includes knowledge of the content (substantive) of the subject domain, and also, the knowledge of the syntactic structure of that discipline (Schwab, 1978). Knowledge of the content includes facts, concepts, laws, theories, and the relationships between facts and concepts in each subject area. While, the syntactic structure of the discipline requires the understanding of evidence and proof within the discipline, or how researchers of the discipline evaluate the knowledge claims. Wilson, Shulman, and Richert (1987) claim that teachers must have two kinds of subject matter knowledge, knowledge of the subject field and knowledge of how to help students come to understand the field.

Many studies investigate the influence of teachers' subject matter knowledge on their teaching. Hashweh (1985) examined the influence of subject matter knowledge expertise on the pedagogical reasoning of experienced teachers. He found that prior subject matter knowledge affects teachers' transformation of the curriculum. More knowledgeable teachers rejected the organization of the textbooks materials. Also, they used different representations to teach particular topics. The same results were found by Wilson, Shulman, and Richert (1987). They found that teachers' subject matter knowledge influences the different ways of representing or transforming subject matter knowledge; metaphors, analogies, illustrations, examples, in-class activities, and home work assignments.

However, in a study outside of science disciplines, Grossman (1990) compared and contrasted different language teaching methods and goals between English teachers who participated in teacher education program and those who did not. Jake, who had no formal teacher education, represented the traditional way of instruction which emphasized the linguistic aspects of Shakespeare's play. He attributed this to his college courses and his experience as an English Major. Steven, who went through a teacher education program, used a more progressive way in his instruction. Instead of focusing on linguistic aspects of the play, Steven emphasized the application of the theme of play into the real situation of students in order to find solution to problems in reality. He even ignored the language analysis. Steven's method stemmed from his teacher education courses and his field experience.

Based on that, I can see how it is important for teachers to be knowledgeable about the subject matter they need to teach for the purpose of teaching and how to organize that knowledge for novice learners. They need to know the structures of their discipline, because without this knowledge, they may misrepresent both the content and the nature of the discipline itself (Shulman & Grossman, 1987). And the results of misrepresentations will increase both students' and teachers' misconceptions about the content to be taught by these teachers. They also need the pedagogical content knowledge that will allow them to transform the conceptual content to their students.

There is no doubt about the importance of the subject matter for teaching purposes. So, it is important to help teachers acquire this knowledge in their teacher education programs and subject area courses.

I have suggested previously (Alshannag 1996) that in order to help teachers acquire subject matter knowledge for teaching purposes, we need to know how the teachers' knowledge of subject matter influences the processes of transformation. What are the kind of skills, and knowledge, needed? And the major thing we need to know is how different kinds of professional knowledge relate to each other. This understanding is essential in order to design curricula that cover these kind of multidimensional relationships. What kind of theoretical framework do we need to initiate these kinds of relationships?

To do so, we need more research on how teachers' knowledge influences their teaching. What is the nature of transformation processes in teaching a particular subject? And how do teachers acquire knowledge of a particular subject matter during their undergraduate studies and teacher preparation programs?

The teacher education programs should be organized and structured in such ways to help teachers gain professional knowledge. They need to acquire different kinds of knowledge. For example, Grossman's (1990) model of teachers' professional knowledge includes four elements; subject matter content knowledge; pedagogical knowledge; pedagogical content knowledge; and knowledge of context.

There are numerous strategies that teachers combine content and pedagogical knowledge to help students learn subject matter. McDiarmid, Ball, and Anderson (1989) discuss that teaching involves a wide range of strategies that relate to the essential purpose of helping others understand. As just one example, Anderson and Smith (1987) have investigated teaching strategies regarding teaching for conceptual change. They found that to best organize lessons for understanding, a science lesson should have the following components:

- The lesson should allow students to voice their preconceptions and make predictions about phenomena
- The teacher should regularly ask students for clarification and explanation of statements
- The teacher should provide discrepant events to help the students recognize their misconceptions.
- The teacher should encourage debate and discussion about evidence with the whole class and amongst themselves.
- The teacher should provide viable alternative scientific explanations to replace the misconceptions. (Anderson & Smith, 1987)

Also, reducing the gap between theory and practice would help teachers to be more professional. One way to do that effectively, is by giving student-teachers more practice inside schools within their program, because what they learned from their experiences will become part of their professional knowledge (Ben-Peretz, 1995). Furthermore, this will influence their teaching styles, decisions, beliefs, and attitudes toward their teaching and teacher education program.

Teaching for conceptual understanding requires the teachers to develop a new conception of what a teacher *is*. Based on the reform agenda, a science teacher inside the classroom needs to be a facilitator and helper to the students, direct them in their inquires, and not simply give them the right answer. Science teachers were required to perform teaching which facilitates students' interactions with the content in order to help students understand scientific concepts and to become more scientifically literate. Students, parents, and administrators have different conceptions of what a science teacher is. They believe that science teachers need to "feed" students with knowledge, answer students' questions, teach students in ways that help them to do very well in achievement on state tests. Too often, these tests are designed to measure the lower level of thinking skills, and are not compatible with teaching science for conceptual understanding.

A more realistic view holds that science teachers are decision-makers. For example, they have some choice about ideas and concepts in science to teach, and power to choose their own curricula, teaching strategies, and assessment based on the background and capabilities of their students. This conception of science teachers contradicts the traditional role of the teacher as implementers of programs and rules established by authorities.

The problem also appears as a matter of a paradigm shift from the traditional conception of science teachers (i.e., teacher-centered, where all classroom discourses oriented and controlled by science teacher) to the new conception of teaching (i.e., student-centered, where teacher's content, teacher's actions, students' actions and classroom environment are mostly directed and controlled by the students with the guidance of a teacher). The issues explored in the foregoing paragraphs in this section will be explored in this dissertation in the context of case studies of four new teachers of secondary school science who recently graduated from two large midwestern universities.

The Significance of This Study

Review of the literature shows that many studies have been done in the domains of science teachers' knowledge and beliefs, science teachers' performance, science teachers' training, and science teacher education programs. But in fact, according to my knowledge there is no research done to examine the relationship among these four domains together. The Salish Project (1997) is the only research study at the national level that investigated the influences of secondary science and mathematics teacher preparation programs on new teachers and their students. The nature of our analysis process in this project was general. We did not do any cross case analysis in-depth.

After the project was done, I started thinking, how could I do my research from the data that we have from Salish? My personal interest, personal background, and professional experiences led to focus on new high school chemistry teachers who were part of this project. This study investigated in-depth the relationship among chemistry teachers' characteristics (i.e. the kind of training that each teacher had), teacher education programs, chemistry teachers' knowledge and beliefs, and chemistry teachers' performance.

This study contributed to the field by providing concrete examples of the nature of the relationship among these four domains especially for teachers who had chemistry as a major or minor in their teacher preparation program.

The significance of this study was its in-depth investigation into the relationships among teachers' characteristics, teacher education programs, teacher's knowledge and beliefs, and teacher's performance.

Furthermore, this study highlighted the teacher preparation program features that contributed to teacher-centered, conceptual, and student-centered teaching style. The implications of this study deepened our understanding of how teacher education programs, including the college science courses that comprise a major portion of prospective science teachers' backgrounds, may be improved to provide a more appropriate education for high school chemistry teachers as well as other science disciplines.

An Overview of the Dissertation

The dissertation contains six chapters. Chapter one provides an introduction of the study problem, the research questions, and a literature review.

Chapter two discusses the conceptual framework of the dissertation. In addition, it describes the methodology of the dissertation. Also, this chapter introduces to the reader the four new high school chemistry teachers and the teacher preparation programs from which they graduated.

Chapter three presents the findings of teacher preparation programs at North Global University (NGU), and the cases of two new high school chemistry teachers who graduated from this program.

Chapter four presents the findings of teacher preparation programs at South Global University (SGU), and the other two cases of new high school chemistry teachers who graduated from this program.

Chapter five provides findings about the linkages among teachers' characteristics, teacher education programs, teacher's knowledge and beliefs, and teacher's performance. Also, this chapter includes section about the limitations of the study that influenced findings.

Chapter six provides conclusions form this study and the major implications to improve teacher preparation programs. This chapter includes the following sections: review of the study; discussion of the research questions; implications of the findings; and recommendations for further research.

CHAPTER 2

METHODOLOGY

This chapter reports on several topics which relate to the specific focus of this study. It provides a description of the Salish project from which the new high school teachers were chosen. It provides an overview about the theoretical framework of the study. Finally, it describes the study design in order to answer the research questions.

Salish I Research Project

This study was carried out in conjunction with the Salish I Research Project[1]. The Salish study, named "Linking Teacher Preparation Outcomes and New Teacher Performance" was funded by the U.S. Department of Education and sponsored by the Council of Scientific Society Presidents (CSSP)[2] (Yager, 1993). The Salish I Research Project was an exploratory study of new secondary science and mathematics teachers from nine universities[3] in the United States during their first three years of teaching (1993-

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[1] Salish I Project is funded by a grant from the U.S. Department of Education and the Office of Educational Research and Improvement (Grant No. R168U30004). However, this study was carried out in conjunction with this project, so any opinions, findings, and conclusions expressed in this dissertation are those of the investigator and do not reflect the views of the U.S Department of Education.

[2] This information was adapted from John Tilloston's dissertation, "A study of the links between features of a science teacher preparation program and new teacher performance with regard to constructivist teaching" (1997).

[3] There were originally ten universities Research Sites participating in this project. However, Norfolk State University withdrew during the second year of the study because the Faculty Associate who coordinated its Research Site activities left the University and no replacement could be found to continue. The other nine universities were: California Sate University, Indiana University of Pennsylvania, Michigan State University, Purdue University, Texas A & M University, University of Georgia, University of Iowa, University of Northern Colorado, And University of South Florida. The Salish reports (1997) lists the institution names, so anonymity of Salish institutions is not possible.

1996). The Salish Project had several goals. One of them was to uncover relationships among teacher preparation and teacher and student outcomes. Unmasking these relationships is intended to inform reform to improve secondary science teacher education programs.

At each site samples of faculty, new teachers who were graduates of their programs, and students in the new teachers' classes participated. Each of the Research Sites selected 10 new teachers (NTs) who were graduates of the participating university and in their first year of teaching in 1993-1994. These NTs comprised Cohort 1. The same procedure was used to select Cohort 2 for the academic year 1994-1995. Some of the institutions also added a Cohort 3 for the academic year 1995-1996, if they had problems of either retention or recruitment of teachers in the first two cohorts. Dropout rates were high due to the heavy demands placed upon NTs and the fact that some of the NTs left teaching during the study.

In total, 175 NTs participated in the study, 16 of these NTs were chemistry teachers (see Table 1) who had chemistry as a major/minor and/or who taught chemistry for high school students during the course of the study. Some of new high school chemistry teachers had more than one year of data (i.e., 2 or 3 years), so the total number of chemistry teacher-years is 32.

Dissertation Framework

Based on several meetings that I attended through Salish study, there was consistent agreement among faculty members and research associates that the orientation

Table1: List of All New High School Chemistry Teachers in the National Sample

Institution & Teacher ID # or Name[4]	Video Portfolio (VP)	Summary of VP	Note
ASU208	No		
ZUP106	Yes	Conceptual	
NGU105	No		Drop-out
NGU(Steve)	Yes	Teacher-centered & Conceptual	
NGU208	No		
NGU(Terry)	Yes	Teacher-centered, with some aspect of student-centered	
NGU323	No		
PUA106	Yes	Teacher-centered	
PUA204	No		
AMT[5]	??	??	??
NGA101	Yes	Student-centered	
SGU(Kathy)	Yes	Teacher-centered, with some aspect of conceptual and student-centered	
SGU(Don)	Yes	Conceptual & Student-centered	
YNC			No One is a Chemistry Teacher
JOR107	No		
JOR210[6]	Yes	Conceptual & Student-centered	
JOR212	Yes	Teacher-centered	
JOR214	No		

of teacher education programs in all of the institutions that participated in Salish study is to help new secondary science teachers to grasp the knowledge and skills that allow them

4 All institution names or abbreviations, and teachers' names are pseudonyms.
5 After several phone calls and e-mail, I could not get information from this university, whether they have chemistry teachers who participated in Salish project or not.
6 During her videotaped lessons, she taught Algebra for 9th grade students, not science or chemistry. So, she was excluded from the study.

to practice constructivist teaching. In other words, all teacher education programs in these universities are designed to help their graduates to practice constructivist teaching.

For the purpose of this study, I selected two of these institutions that had new high school chemistry teachers who demonstrated different teaching styles and who had video portfolios. The two institutions were North Global University (NGU), and South Global University (SGU).

The goals of teacher preparation programs at North Global University is to help prospective secondary science teachers to acquire the knowledge and skills that are essential for them to be a constructivist teachers (teacher education faculty and their courses syllabi reflect this view). After the first Salish cohort, NGU overhauled its teacher education. NGU was a member of the Holmes Group, and reshaped its program from a four year program with a semester of student teaching to a five year program with a full-year internship program (See Holmes Group, 1986).

Also, Steve, a new high school chemistry teachers who graduated from this program believes that the philosophy of teacher education program at NGU is a "constructivist-orientation." When he was asked, "what was the philosophy of your teacher education program related to science education and to science teaching?" He says:

> "Um, to take science constructively and to make it something that the students can use to better themselves and make themselves more functional in society instead of making science a set of facts or set of knowledge that some people have and some people don't, *so it was kind of that everyone can learn science, everyone can use science, the more that students can use science to solve problems the better*. That was kind of the idea that I got" (NTI, 1996). [emphasis added]

So, the message that Steve processed about the philosophy of his teacher education programs is that science should be taught to ALL students, and all students are able to learn, understand, and use science in a way that could help them solve problems. Thus, Steve's image about the philosophy of teacher education programs at NGU fits with the mission of AAAS's, "Science for All Americans" in order to help students become "scientifically literate" and promote scientific literacy (AAAS: Science for All Americans, 1990). The only way to achieve this goal is by designing teacher education programs that are structured in a way to teach for conceptual understanding.

Likewise, the teacher education program at SGU is also designed to support prospective science teachers with knowledge and skills that help them to become constructivist teachers. Tilloston (1997) in his study found that several features of science education program at SGU were linked to constructivist teaching behaviors exhibited by the new secondary science teachers. For example, he found that NTs displayed student-centered learning activities in their science teaching which mirrored the use of these same strategies in the SGU teacher education program. Also, NTs used many authentic assessment strategies in their teaching that were advocated and implemented by SGU program faculty in their courses.

Moreover, most of the faculty at this program believes that the primary goal of this program is to prepare prospective science teachers to become constructivist teachers. This view about the philosophy of the program was mentioned by the program director, when he said that, "STS [science-technology-society viewpoints] and constructivism fit together." When the interviewer asked him to elaborate more about how those two things play a part in the program in terms of philosophy of teaching science, he says:

> "Taking advantage about what we know about learning, which they you have to change your teaching of that if you want to use the word, 'constructivist,' teaching. Although, the constructivist never really talk about teaching. STS to me is doing two big things-it's making it legitimate to use the human made role as a match as well the natural world and it also is providing a social context for both study and learning. *I argue that science is a social activity.* It's what human beings do, there is a society there and that *science is a social activity because you can't have science by one person doing an experiment and being convinced by him or herself. The mere fact that science demands a community of people to agree with the interpretation of nature makes it a very social activity.* That to me are the two aspects of STS that I think characterize it" (Preservice Program Interview-Teacher Education Faculty Interview, 1996). [emphasis added]

The study aimed to investigate in depth how the teacher preparation program features influence new high school chemistry teachers' knowledge, beliefs, and performance. More precisely, the study investigated how those program features in the two institutions (i.e., both programs emphasize that prospective science teachers need to acquire the knowledge and skills that could help them to teach for understanding) could contribute to different teaching styles: teacher-centered, conceptual, and student-centered.

For the purpose of this study, the definitions of these terms are adopted from (The Final Report of the Salish I Research Project, June 1997, P. 9):

- Teacher-centered, defined as beliefs and actions in which the teacher: is the chief conduit of most of the content knowledge to be transmitted to students, has responsibility to organize and "deliver" content knowledge to students, stresses the factual and descriptive nature of science (content and process), seldom employs examples or connections in science, emphasizes the scientific methods and rote learning, employs principally teacher-directed instructional methods with minimal students' input, allows students rarely or infrequently to generate questions or procedures, permits few student-student interactions to occur, focuses the majority of assessment on short answers. Typical teacher actions include: a) presentation of information to students; b) use of textbooks, videos, and other resources as a source of instructional content and learning activities; c) drill and rehearsal of information in varied ways including review games that mimic TV quiz programs like "Jeopardy"; and d) fact-centered tests with only small emphasis on applications of information to evaluate student learning. For example, teacher-centered teachers tend toward more factual content with very little real world applications, a more limited repertoire of teaching strategies, more student seat work, and tests that are fact-centered.

- Conceptual, defined as those beliefs and actions in which the teacher emphasizes the explanatory nature of science (content and processes are integrated, generates examples and connections in science, employs many teacher-centered instructional methods, focuses labs and demonstrations on concepts, seeks to change unscientific ideas, encourages some student-student interactions and student-initiated activity, encourages students' questions to be procedural and conceptual. Teachers in this category appear to place subject matter knowledge as the central focus of their beliefs and actions instead of placing teaching or students at the center. Content tends to be explanatory, organized around important ideas (key concepts). For example, processes of science address "how we have come to know" and other important ideas of science. Teaching strategies tend to be teacher-centered, but also include hands-on activities, group work and discussion as ways of helping students to clarify understanding of ideas. Conceptual teachers tend to use frequent homework, quizzes, and tests to reinforce and check on students' understanding of important concepts.

- Student-centered, defined as those beliefs and actions in which the teacher stresses the nature of science as negotiated understanding and inquiry, shares the construction of science examples and connections with students, employs more student-centered instructional methods and investigations, focuses questions on students' ideas and instructional goals, focuses assessment on understanding and applying ideas, encourages students' questions to be conceptual, encourages student-student interactions to focus on understanding, encourages students to initiate activities and to contribute examples and analysis (inquiry-orientation). Students gain knowledge through their own actions including hands-on activities, group work, project work, and laboratory investigations. It is the students' responsibility to acquire and process their own knowledge of science. The teacher acts as the facilitator and guide in this activity. Teachers' actions in this category include: a) organizing activities for students to gain experiences that will lead to learning, b) asking questions of students to guide them in learning from activities, and c) using alternative forms of assessment to appraise students' learning. In practice, there sometimes is a dissonance between student-centered teachers' interactions with students and their emphasis on content. Some student-centered teachers provide "fun" activities for students, but fail to place sufficient emphasis on science content to provide sound learning opportunities for them.

The terms; Teacher-centered, conceptual, and student-centered are general categories used to describe three teaching styles or teaching beliefs. One rich instrument used to analyze videotapes to identify teaching style was the Secondary Teacher Analysis Matrix (STAM-Science version) (Gallagher, & Parker, 1995). This instrument differentiates teaching styles into six categories: Didactic, Transitional, Conceptual, Early Constructivist, Experienced Constructivist, and Inquiry Constructivist.

The Teachers' Pedagogical Philosophy Interview instrument (TPPI) (Richardson, & Simmons, 1994), which presents information about teachers' knowledge and beliefs, did not have a special categorization like didactic, conceptual, constructivist, and etc., In order to be coherent with other instruments, Richardson and Simmons developed a categorization which includes Prescriptive, Didactic, Conceptual, and Constructivist levels. In the Salish Project report we agreed on a common language for categorization of teaching styles and beliefs. The categories were as follows: (a) teacher-centered (prescriptive, didactic, and transitional), (b) conceptual, and (c) student-centered (early constructivist, experienced constructivist, and inquiry constructivist.).

In order to analyze teachers' knowledge and beliefs, an elaborate coding scheme for the Teachers' Pedagogical Philosophy Interview was developed. The length of the interview and the number of participants required that a scheme be developed to collapse those codes so that analysis could involve all one hundred focus teachers and the TPPI interviews they completed "Supercodes" were developed for this purpose at the University of Georgia under the tight time constraints of the Salish Project. Sometimes, these supercodes created some problems in analyzing teacher's knowledge and beliefs for two reasons.

The first problem is that these supercodes were forced to fit with the other instruments' conceptual framework (i.e., STAM). So, this caused some difficulties in finding practical meaning for some categories. For example, these supercodes describe a teacher who supports a state or mandated curricula as a teacher who has didactic teaching beliefs, but in fact some of these curricula or state objectives aimed to help teachers to teach for understanding. So, in this case, these teaching beliefs could be coded as an early constructivist teaching beliefs in stead of didactic.

The second problem arises for any questions that were coded with an "other" code. This led to classifying some of the teacher's knowledge and beliefs under this category without having any ideas about where that kind of belief belongs. For example, if a teacher believes that he can decide when to move from one concept to another by asking students to draw concept maps, he receives an "other" code. This kind of teaching beliefs could be categorized as other, but in fact this kind of teaching beliefs suggests that this teachers is focusing on students' understanding and that teaching beliefs could be coded as early or experienced constructivist teaching styles. So, the limits (i.e., a few practical codes were defined for each question) of these codes for each question made the analysis of teacher's knowledge and beliefs difficult.

To overcome this problem in analyzing teacher's knowledge and beliefs, I discussed any teacher's responses that I faced a problem with the supercodes with a senior research associate who was involved in Salish project from the beginning and who represented NGU in most of the Salish meetings. Some of these meetings were organized to address issues related with study methodology and analysis.

Sample Selection

This study used these three general terms that describe teaching styles or beliefs, teacher-centered, conceptual, and student-centered, to select the new high school chemistry teachers from the national sample. I selected those new high school chemistry teachers in their second year of teaching. My rationale for this selection is that teachers in their first year of teaching almost always spend more time working overcome their constraints (for example, time/opportunity, classroom management, students' personal life, and etc.). And the number of teachers who had three years set of data was very small.

From new high school chemistry teachers with two years of teaching experience I selected those who had video portfolio data. The total number of those teachers is 9 (Teachers from AMT University are not included because they are not determined yet, plus it is not allowed to watch these videotapes). Table 2 shows those teachers, the institutions from which they were graduated, and their teaching style. Based on their teaching style, I chose two teachers from the same institution who had different teaching styles (i.e. Teacher-centered vs. Conceptual & student-centered). After a long process of communication that I did with these institutions in order to get a significant data that fit

Table 2: New High School Chemistry Teachers Who Had Two Years of Experience Across the National Sample and Their Teaching Styles

Institution & Teacher ID #	Video Portfolio (VP)	Summary of VP
ZUP106	Yes	Conceptual
NGU (Steve) *	Yes	Teacher-centered & Conceptual
NGU (Terry) *	Yes	Teacher-centered, with some aspect of student-centered
PUA106	Yes	Teacher-centered
NGA101	Yes	Student-centered
SGU (Kathy) *	Yes	Teacher-centered, with some aspect of conceptual and student-centered
SGU (Don) *	Yes	Conceptual & Student-centered
JOR210	Yes	Conceptual & Student-centered
JOR212	Yes	Teacher-centered

with the sampling criteria. I ended up with two institutions that each had two new high school chemistry teachers. The total number of subjects in this study was 4 new high school chemistry teachers with two years of teaching experience (those teachers are identified with * by the end of their pseudonyms, see Table 2).

<u>North Global University (NGU)</u>

The teacher preparation programs at NGU consist of two main parts: The science content program which took place at the science disciplinary departments; and the teacher education part which took place in the college of education. This program was selected in Salish study because it was recognized as leading reform efforts in teacher preparation in the United States. This included the implementation of a five-year, research-based teacher certification program that culminates with a full-year internship. The internship and field experience prior to that are designed to be "guided practice" for the teacher candidate. One of the primary goals of NGU's program is to certify teachers who are "well-turned novices." These well-turned novices are hopefully well prepared to become constructivist teachers.

From this program I selected two new high school chemistry teachers as case studies in order to investigate the influences of teacher preparations programs features on their performance, knowledge, and beliefs. Both teachers graduated in the same year with the same major and minor[7].

Terry Wheaton (a pseudonym) is a new high school chemistry teacher in her early twenties. She earned her degree from NGU in 1994. She was a biology major and chemistry minor. Her areas of teaching certification are in biology and chemistry. She taught 9th grade general science to at-risk students. Her school was in a medium-sized city with typical urban problems. Her students were at-risk and generally from lower SES families.

Steve Brook (a pseudonym) is a new high school chemistry teacher in his early twenties. He earned his degree from NGU in 1994. He was a biology major and chemistry minor, and certified to teach in both areas. He taught 10th grade biology and 11th grade and 12th grade chemistry. His school was in a small town where local employers include agriculture, an insurance company headquarters in the nearby small city and a large complex of state prisons.

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[7] NGU graduates in this study had one year of experience as an internship and the second year of their teaching is a first year they got paid. So, in interpreting their data we need to keep this point in our mind.

South Global University (SGU)

The teacher preparation programs at SGU also consists of two main parts: The science content program which took place at the science disciplinary departments; and the teacher education part which took place in the college of education and the science education center. This program was selected in Salish study because one of easy access to the site (Marshall & Rossman, 1989), and for the rich mix of the many processes, programs, features, and experiences present when compared to several of the nine institutions participating in the Salish I Research Project (Salish Program Description, 1994).

For the purpose of this study, I chose from this program two high school chemistry teachers who demonstrated two different teaching styles in order to see the influences of teacher preparation program on their knowledge, beliefs, and performance. These two teachers graduated from the same teacher education program at SGU, but they experienced two different science content programs. The two cases are:

Don Miller (a pseudonym) is a second year high school chemistry teacher in his mid-twenties. In1994, he graduated from SGU with a biology major and chemistry/physics a minor. His area of teaching certification are biology, chemistry, physics, and general science. He taught 9th grade physical science at s small town in a rural, mid-western community of 2,500 people.

Kathy Brown (a pseudonym) is a second year high school chemistry teacher in her upper-thirties. She was a biology major and chemistry minor. She graduated with a science degree in 1978 from a large mid-western university that was not SGU. Her areas of certification are biology, chemistry, physics, and general science. She taught 9th grade physical science and college credit-biology at a small school in a small city of population under 25,000.

Data Sources

This study used data from Salish I Research Project. More data about teachers' characteristics were collected through e-mail interviews that occurred as I was writing the dissertation, more than one year after the end of the Salish study. The following are the specific domains investigated and the data sources which support these findings:

- New teachers' characteristics which were investigated through the Salish Inventory for Demographic Evaluation of Schools and Teacher Education Programs (SIDESTEP). This instrument was a source of contextual and demographic data related to each new teacher. More data about teachers' characteristics were collected through phone e-mail interviews.
- Teacher preparation program features which were investigated through science and teacher education faculty perceptions of the nature of study in science and teacher education (Preservice Program Interview: Science Faculty Form and Teacher Education Faculty Form), new teachers perceptions of the nature of their science and teacher education study (Preservice Program Interview: New Teacher Form), syllabus analysis form, and catalog description of teacher education program requirements.

- New teachers' knowledge and beliefs which were measured using their responses on the Constructivist Learning Environment Survey (CLES), the Teachers' Pedagogical Philosophic Inventory (TPPI), and the New Teacher Interview (NTI);
- Classroom performance of new high school chemistry teachers in their second year of teaching which were investigated through the video portfolio which were analyzed using STAM, and their students' responses on the Constructivist Learning Environment Survey (CLES).

Data Analysis

This study used Salish methodology in coding and analyzing data in order to describe the knowledge, beliefs, and performance of those four teachers. A case study design was used to describe each teacher's knowledge, beliefs, performance (Yin, 1984). In addition to that the case studies covered each teacher's background. It explained the kind of subject matter that each teacher had experienced during his/her pre-service teacher education program, the kind of chemistry training they had, the background in math and physics they had, and the teacher education training they experienced.

Furthermore, this design would help to explore in depth the linkages among different teacher preparation program features and new secondary science teacher's knowledge and beliefs, and their teaching. Using the case study design in this dissertation is essential because of the richly detailed data from this study that includes surveys, questionnaires, interviews, video-portfolios, and documents (Stake, 1995; Yin, 1984)

Teacher preparation programs were analyzed by using data from Preservice Program interview for both science and science educators faculty, Syllabus Analysis Form, and catalog description of teacher education program requirements. After there, data were organized in a matrix, descriptions were developed of the features of different teacher preparation programs.

TPPI supercodes were used to describe new chemistry teacher's knowledge and beliefs. By using these supercodes teachers' knowledge and beliefs in the following domains could be explained: teacher's view of content; self as a teacher; teacher's actions; students' actions; environment; context; diversity; and philosophy of teaching.

Video portfolios were used to analyze the teaching performance for each new high school chemistry teacher. The video portfolio includes; three consecutive class period videotaped for science lessons; classroom observation unit content journal and daily journal. The Secondary Science Teacher Analysis Matrix (STAM) was used to analyze teachers' performance inside the classroom. This instrument helped me to differentiate teaching style for each teacher into six categories (didactic, transitional, conceptual, early constructivist, experience constructivist, and inquiry constructivist). By using STAM, the teaching style for each teacher in the following domains could be explained: teacher's content, teacher's actions, students' actions, resources, and environment.

More information about teacher's and his students' beliefs can be identified by using the Constructivist Learning Environment Survey (CLES). There are separate but comparable forms for students and teacher. This instrument contains six sub scales: personal relevance scale, scientific uncertainty scale, critical voice scale, shared control scale, student negotiation scale, and attitude scale. However, CLES data for the two NGU graduates very limited. As a result, CLES data were presented only for the two SGU graduates.

The maximum score for each sub scale is 35 and the minimum is 7. A scale score of 35 meant that the students'/teacher responded "almost always" on each item. A scale of 28 meant the students' average/teacher response to the item on that scale was "often." A scale score of 21 corresponded to response of "sometimes" and a scale score of 14, to a response of "seldom." Finally, a scale score of 7 meant that the student/teacher responded "almost never" to each item, (Adapted from Salish, 1997, P. 7-8).

A cross case analysis was done to investigate in depth the relationships that may exist among chemistry teachers' characteristics (i.e. the kind of training that each teacher has), teacher education program features, chemistry teachers' knowledge and beliefs, and chemistry teachers' performance. Also, cross case analysis could highlight which program features or teachers' characteristics contributed to teacher-centered, conceptual, or student-centered teaching.

CHAPTER 3

TEACHER PREPARATION PROGRAMS AT NORTH GLOBAL UNIVERSITY AND THE CASES OF TERRY & STEVE WHO GRADUATED FROM THIS PROGRAM

This chapter consists of three interrelated sections. The first section focuses on the teacher preparation programs at North Global University. This section divided into two parts: Part (a) focuses on science content program which reported the analysis results of the science content courses that new secondary science teachers completed in the science disciplinary departments. Part (b) focuses on education courses that new secondary science teachers experienced in the college of education, including general education courses.

The second section focuses on the knowledge, beliefs, and performance of Terry, a graduate of teacher preparation program at North Global University. Finally, the third section focuses on another graduate of North Global's program, Steve.

Section One: North Global University Teacher Preparation Programs

In this section I described features of teacher preparation programs at North Global University. Whenever teacher preparation programs mentioned, it means the two main parts of this program: the science content program which took place within the science departments; and the education component which took place in the College of Education.

The following sources were used to collect data as part of the Salish study: a) Data Sheet for describing formal program operated by institution; b) Preservice Program Interview-Science Faculty Form; c) Preservice Program Interview-Teacher Education

Faculty Form; d) Syllabus Analysis Form; and e) Preservice Program Interview-New Teacher Interview Form. Data were transcribed, coded, and analyzed according to the plan laid out by the Salish Project planners (Salish, 1997).

In order to gain a clear vision about teacher preparation program features at North Global University I divided the analysis outcomes into two parts: 1) Science Content Program, and 2) Education Program. The reasons for separation the two components lie in the substantial differences between them. After initial analysis of these data, it was evident that it would be appropriate to treat them as a two separate programs (Duggan-Haas, 1998).

Part a: Science Content Program at North Global University

Science content program features at North Global University were mainly extracted from Steve's and Terry's responses on the Preservice Program Interview (New Teacher Interview, NTI), Academic Program: Descriptions of courses, (1995-1997), and Preservice Program Interview- Science Faculty Form. A summary of science content program features is included in Table 3.

1. Semester Hour Requirement

Prospective secondary science teachers are required to take their major/minor courses in the science disciplines departments. Science majors are required to complete 41-47 semester hours in their majors and 18-24 semester hours in their minors. Also, they are required to take 5-8 semester hours in mathematics.

Table 3: Science Content Program Features Matrix for North Global University

Feature/data Sources	Terry	Steve	Science Faculty: Jean	Science Faculty: Diane	Summary
Objectives	Content oriented.	Content oriented	Traditional objectives	Rethink & relearn	Content oriented
Instructional Strategies	Lecture, recitation, lab	Lecture, recitation, lab	Lecture, recitation, lab is separate	Lab	Lecture, recitation, lab
Instructional Resources	Textbook, lab books, & equipment.	Textbook, lab books, & equipment	Textbook, computer/ home work	Literature, hands-on, no lab manual, & J. of Chem. Ed.	Textbook, lab, computer/ home work, equipment, & journals used occasionally.
Methods of Assessment	Mostly multiple choice tests, lab reports, few exams	Majority multiple choice tests, lab practical, few papers	Multiple choice tests, final, quizzes, computer graded home work	Research project, lab write-ups,	The majority were multiple choice tests
Cooperative learning	In the lab only	40% of the lab time	Once a week in recitation	All of the lab stuff is done in groups of 4	Mostly in the lab
Courses Audience	One course: Science lab for teachers	One course: Science lab for teachers	No, for all science majors	All science majors	All science majors, except one lab

Table 3 (cont'd)

Feature/data Sources	Terry	Steve	Science Faculty: Jean	Science Faculty: Diane	Summary
Actual Research	One project	No	Just in honor classes	Independent research projects	Few research experiences available to undergraduate.
Important experience	Physical Chemistry: small size; discussion; instructor; demonstrations; challenging exams; & real world	Botany class: lab tied into the lecture; real lab; structure; a lot of responsibility.		Steve & Terry pointed to this course, science lab for teachers, as an out standing class	A class which ties a lab into lecture: small size and real world applications are the most important features.
Student faculty relationship	Informal: helpful if you went to the office hours	Informal: most faculty were real open	Informal	Informal	Informal relationships with faculty
Program Structure/ Cohort	No cohort in science classes	No cohort in science classes	No, cohort in science classes	No, cohort in science classes	No cohort in science classes
Purpose of studying science	Pre-medical	Pre-medical technology			Pre-medical technology
Philosophy of Science	process	Body of knowledge	Promote science literacy.	Dynamic, students need to learn about the social, historical, & philosophical nature of science.	Knowledge, process, dynamics, social, historical, philosophical, & science literacy.

2. Course Objectives

Terry and Steve mentioned that transmission of factual content was the primary purpose of the science courses (i.e., science courses were content oriented). Steve described the objectives of these science courses, as he says:

> "A typical science course, uh, included probably three days a week of lecture in varied size lecture halls and may or may not have included a lab, *it was pretty content-intensive,* um, *trying to cover as much material as possible* within a ten or fifteen week period, depending on whether I was on semesters or terms" (NTI, 1996). [emphasis added]

This image of the science courses was confirmed by Jean (a pseudonym), who was doing a research on the Chemistry 141 course, an introductory chemistry course that offers by the Chemistry Department at North Global University. She says that:

> "The course is designed to *teach the traditional objectives of general chemistry*: stoichiometry, atomic structures, bonding, phase changes, gas laws, some basic reaction types including acids and bases, basic thermodynamics, and equilibrium" (Preservice Program Interview-Science Faculty Form, 1996). [emphasis added]

Even though this is the predominant image of science courses, Diane

(a pseudonym) who taught a lab for prospective secondary science teachers (ASC 409) in the College of Arts and Sciences sees that the objectives for her course is not content oriented, but in fact it is to help new secondary science teachers to rethink about the "stuff" they have learned (i.e., it is a reflection on their previous learning), as she says:

> "The objectives for the course are basically for students to rethink stuff they have learned already, so nothing is new. At least it's not supposed to be, though that's not always true. But it's pretty much old stuff they have had in introductory level courses. Some of the chemistry goes beyond that, but it's not very complicated

stuff. So it's to rethink it, relearn it, put it together in some way in their heads" (Preservice Program Interview-Science Faculty Form, 1996).

3. Instructional Strategies

The most common instructional strategies in these science courses were lectures, recitations, and labs, as Terry says:

> "*Mostly lecture. Big huge lecture hall*, and then there would be recitations, like, once a week. And then labs. We would have, like a three hour lab or whatever, that we'd have, so, mostly, if I was to succeed in a science class at Global I'd just take really good notes" (NTI, 1996). [emphasis added]

Steve supported this picture, as did evidence from program description and interview with the two faculty members in science.

4. Instructional Resources

Instructional resources in these courses were mostly textbooks, lab manuals, equipment, and computer home work assignments. Steve in his NTI mentioned some of these resources, as he says:

> "Usually it was an overhead projector with some notes and the, uh, professor discussing them, talking about them. It wasn't always like that. I had classes with lab sections where a grad assistant would, we did discussions in the lab section or the recitation, but usually it was lecture hall" (NTI, 1996).

In contrast to this image, Terry had an interesting biology class in her science content program where students used many instructional resources, as she says:

> "I had one biology class where we did a lot of stuff with the kingdoms and mostly we looked at slides that were already prepared, and then there was one day where we looked at squids. And I think we might have looked at a couple of other things that day. Um, and then books, and then what else? As far as, like, equipment that I had to buy, I think I just bought goggles and then I bought a molecular model set for my organic chemistry class, cause I was really confused, so the teacher suggested I get that" (NTI, 1996).

5. Methods of Assessment

Students in these classes were typically evaluated by using multiple choice tests. In the lab, students were evaluated through lab write-ups. For example, Diane says, "We do a lot of microbial biology and we have a lot of lab write-ups for that." Also, practical exams were used in the science labs. In addition to that in Chemistry 141 students were evaluated through the final exam, quizzes, and computer graded homework assignments which consisted of numerical problems, true/false, and multiple choice questions.

6. Cooperative Learning

In science classes, Steve and Terry refer to their group work in the lab as a cooperative learning. However, they worked in groups in lab (i.e., lab partner) but the nature of that work in the lab usually does not reflect that instructors used cooperative learning as an instructional strategy. For example, Steve had 40% of the lab time worked with partner. Terry worked most of the time in the lab in groups. Also, students in Diane's Class worked in groups, too. She thinks that working in groups is good and bad, as she says:

> "They work in groups. They do certainly all of the lab stuff in class in groups and usually in groups of four, because that's what works out at the tables. That's good and bad. The good part is that they work in groups, and the bad part is that they do what we don't want students to do, and that is to split up the work so that not everybody is doing what needs to be done. That's just something I need to help them with. The independent projects, I encourage them to work in pairs, but it's not a requirement. It turns out that some do it alone and some do it in pairs. I'd say it comes out that slightly more work in pairs than do it alone" (Preservice Program Interview-Science Faculty Form, 1996).

7. Course Audience

Both Steve and Terry took Diane's class (science lab for new secondary science teachers), and that was the only class designed for preservice teachers in the science disciplinary departments. In this class Diane tried to cover the four basic disciplines in science: physics, chemistry, earth science, and biology. Because of her expertise in biology and chemistry, "it tends to be more of that." In other words, based on her expertise, she focused more in chemistry and biology.

8. Actual Research

Neither Terry, nor Steve reported that they had an actual research experience in their science courses. However, Terry mentioned that she did a project in her physical chemistry class. Actually, she did not give any information about this project. Students in Diane's class did independent research projects as she mentioned. However, both Steve and Terry said they did not complete a research project but Diane says that it is part of her course, which both of them completed. Jean mentioned that:

> "None of the students in this course [chemistry 141] do research or work in labs. However students in the equivalent honors course take a lab which consists of doing independent projects. However they are done in a teaching lab[1], not a research lab" (Preservice Program Interview-Science Faculty Form, 1996).

It appears that Terry and Steve did not view the projects in Diane's class as research, in the traditional sense.

9. Important experiences

Terry considered her physical chemistry class as an exceptional experience which stands out in her mind. She thinks that this class was different because it was smaller size, so people can have discussion. Furthermore, the instructor in her opinion was an

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[1] Jean refers here to Diane's class, a lab for prospective secondary science teachers (ASC 409).

excellent chemistry instructor because he taught chemistry by using a lot of demonstrations. Terry found that this class helped her to understand the chemistry concepts, as well as influencing her teaching. As she says:

> "Physical chemistry, my p-chem class, was really important because I kind of, *there was a lot of things I didn't understand about chemistry before I took that class* And I find myself now going back to that a lot, especially when I taught chemistry this fall Like, when we talked about the gas laws and stuff, I took a lot with me from that class" (NTI, 1996). [emphasis added]

This class helped her not only to understand the content of the physical chemistry class itself, but also to understand chemistry in more general:

> "Yeah, cause chemistry always, I didn't do, chemistry I didn't do as good in my classes a biology. I don't know, there's a couple reasons why, but *that class made me actually like chemistry. Before that I didn't even like it.* I just kind of did it because it was, I had to take chemistry for my biology major, so. And then, while I was taking this class, *I almost, changed my major to chemistry cause I thought chemistry was so cool.* Ha, ha" (NTI, 1996). [emphasis added]

For Steve, the most influential science courses that stands in his mind was a botany class. This class was an important one to him because it linked lab and lecture, as he says:

> "It seemed like the lab tied into the lecture part of the class instead of being completely separate. They related to each other so you could, uh, you know, *link ideas between the two instead of in most science class I had, like chemistry and that, the lecture portions and the lab portions seemed unrelated to me, totally different*" (NTI, 1996). [emphases added]

10. Student-Faculty Relationships

The nature of student-faculty relationships seemed to be informal. Steve describes this relation as it "wasn't bad, I'd say most of the grad assistants and professors were real open to discussion and talking to their students, for the most part." Terry thinks that, "most professors were helpful if you went to office hours!"

11. Program Structure/ Cohort

None of them were members of a cohort in science classes. In these science classes the students were from many different majors. Pre-medical students were dominant.

12. Purpose of Science Study

Steve and Terry mentioned that they had science as an area of study because they want to enter into the medical field. As Steve says:

> "...originally I started out in medical technology just to be pre-med. and uh, I had noticed that a fair number of the students in my classes were um, pre-med. majors so I'd say that was kind of the track I was in, anyway, even though I had switched the first or second year over to education" NTI, 1996).

13. Philosophy of Science

Neither Diane nor the program description reported anything about the philosophy of science program. However, Jean who had joint appointment within College of Education and College of Natural Science, reported that science is recognized as a, "body of knowledge." She believes that science courses should promote "science literacy." Jean says:

> "My personal interest in this and similar courses is a desire to promote science literacy. *A quarter of the students fail this course [chemistry 141] and many pass without understanding much at all*" (Preservice Program Interview-Science Faculty Form, 1996). [emphasis added]

Therefore, according to Jean's views, science courses need to be reorganized to help college students to become scientifically literate, even students who major in science (AAAS, 1998; AAAS, 1990; NRC, 1996).

Part b: Teacher Education Program at North Global University

Teacher education program features at North Global University were mainly extracted from Steve's and Terry's responses on the Preservice Program Interview (New Teacher Interview, NTI), Preservice Program Interview- Teacher Education Faculty Form, Academic Programs: Descriptions of Courses (1995-1997), and some of the Teacher education Courses Syllabi. A summary of teacher education program features is included in Table 4.

1. Admission Requirements

At North Global University no undergraduate degree were required for admission at teacher education program, yet 56 semester hours with a cumulative grade-point average (GPA) of 2.5 or higher is required. Additional requirements were completion of specific courses with a minimum grade. Interviews and writing samples were also required[2].

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[2]Note: some program requirements have changed.

Table 4: Teacher Education Program Features Matrix for North Global University

Features/data Sources	Terry & Steve	Teacher Education Faculty	Teacher Ed Courses syllabi
Objectives	Diversity, teaching science for all students, Attitude (i.e., Education is a profession)	Teacher as a reflective practitioner, teaching as profession, teaching model, student teaching, assessment, unit planning, constructivist learning environment, & nature of science.	Diversity, become an effective teacher, teaching as a profession.
Instructional Strategies	75% of the time cooperative learning (method courses)	Lecture, group work, cooperative learning, problem solving, discussion, projects, observations, videotape analysis, hand-on, labs, modeling, & technology-based.	Group project, group work, observations, discussion, & teaching
Instructional Resources	Textbooks, course packets, equipment, & articles	State Essential Goals & Objectives, NSES, Project 2061 Benchmarks, internet, readings, lab manual, textbook, audio-visual, computer software, course packets, & field experience guides.	State Essential Goals & Objectives, textbooks, articles, course packets, computer, & videotapes,
Methods of Assessment	Papers, interviews, & projects	Field assignments, portfolio, reports, papers, working labs, essay exams, oral exams, home work, performance, presentations, actual teaching, projects, lessons/unit plans, journals, & interviews.	Research project, group project, papers, portfolio, journals, work plans, participation, presentations, discussion, interviews, & resource notebooks.

Table 4 (cont'd)

Features/data Sources	Terry & Steve	Teacher Education Faculty	Teacher Ed Courses syllabi
Cooperative learning	Mostly in the methods courses (i.e., student-centered)	Most of the time students working in small groups	Small working group & groups project
Research Experiences	Field experience	Field experience Just beginning to use action research.	Field experience: Teaching, group project
The Internship	Fall & Spring teaching in high schools.	One year long. Separate and connected to other courses	One year long. Separate and connected to other courses
Field experiences	Terry taught 4 biology classes & co- taught a chemistry class. Steve taught chemistry & biology (10-11th) grades	Teaching, observing, tutoring, planning lessons.	Observations, teaching, & videotaping.
Supervision	Content area field instructor, general person, & mentor teacher,	Field instructors (i.e., personal mentoring relationship) & mentor teachers.	Field instructors & mentor teachers.
Important Experience	Reflection/ Inquiry in Secondary Science Teaching Practice TE 802; TE 804		
Student faculty relationships	Informal (i.e., on the first name bases), open communication	Informal	
Professional Linkages	Terry: NSTA & NABT Steve: NSTA & State-STA	Required and encouraged	
Program Structure/ cohort	Terry: Team 1 Steve: Team 2	Teams & cross teams: 1, 2, & 3.	

Table 4 (cont'd)

Features/data Sources	Terry & Steve	Teacher Education Faculty	Teacher Ed Courses syllabi
Program Relationships	She learned how to teach the content. They were not correlated very well	No relationships with people who teach the basic science courses. Informal (e.g., through personal contacts and experiences).	
Prior Career	Neither Terry nor Steve had this experience		
Philosophy of TE program	To help ALL students to learn, inquire about the world, students' prior knowledge, life long learners, problem solvers, & critical thinkers, . To make the students more functional in society by using science.	Constructivism: _ Secondary school students should have experiences to construct their own knowledge. _ Teachers should empower students as learners. _ Teachers should be reflective practitioners. Teaching should be interactive. School students should engage in solving problems. Less is more. Teaching as analytical decision making. Value diversity of students. Use assessment data to guide & modify instruction. Job of teacher is to nurture development of content knowledge and/or skills. Teaching and learning should on students' personal relevance. Teachers should adopt a research-based, best practices-based approach. Teaching is based on practical, situational, reality-oriented analysis of the classroom. Teacher is a professional.	

2. Types of Certification Awarded

The program awards state certification in secondary (7-12), by subject matter. Students typically receive dual certificates; that is they are certified in both their majors. The college certifies over 20 secondary science teachers/year.

3. Semester Hour Requirements

Science majors are required to complete 41-47 semester hours in their majors and 21 semester hours in a teaching minor. They are required to take 5-8 semester hours in mathematics. There are 17 semester hours of required science methods courses. There are 3 semester hours of required general methods courses. No semester hours are required in history and philosophy of science courses, but it is offered as an elective course.

There are no semester hours of required STS course work. There are 5-8 semester hours of required psychology foundation courses. There are 5-8 semester hours of required social foundation courses. There are 5-8 semester hours of required multicultural education (diversity) courses. No semester hours are required in history of science, philosophy of science, or in computers and related communications technology courses for prospective secondary science teachers, technology and art in the nature of science are embedded in several teacher education courses.

4. Program Purpose/Goals

Jack & Jeff (pseudonyms) are professors in Teacher Education department at North Global University. Jeff interviewed Jack through Salish-I Research Project by using Preservice Program Interview-Teacher Education Faculty Form (1996). The nature of this interview was not a traditional interview between interviewer and interviewee, but in fact, it was a conversation between two faculty members who are teaching on the same department for a long period of time. This conversation took place in Jack's car while they were going to lead a workshop for science teachers in a city lies in the northern part of the state.

Jack & Jeff taught these courses: curriculum; methods; and student teaching in the academic learning program, a former program in the department of teacher education. The sequence of these courses in this program were mentioned by Jack, as he says "that was winter of Junior year was the curriculum course; spring of the Junior Year was the methods course followed by the Senior Year was student teaching." So, preservice science teachers had one and half years of field experience in this program.

Since 1993 the structure of teacher education program has been changed into a new program, which is referred to as the "Standard Program," a program with over two years of field teaching experience. Jack and Jeff still teach science education courses in this program from which Terry and Steve graduated. Both Terry and Steve had Jack and other faculty as instructors. This program consists of the following courses: TE 301; TE 401; TE 402; TE 501, TE 502, TE 802; and TE 804.

Jack says that:

> "The new program was, the group that you [Jeff] had was the very first group that started the new program [it was in Fall 1993], so [instructor name) and [instructor name] and I had them for 2 years...we had picked them up at the beginning of their Senior year and continue with them through their intern year and *this is a model that I think in retrospect has become very powerful*" (Preservice Program Interview-Teacher Education Faculty Form, 1996). [emphasis added]

The goals for TE 301 (Learners and Learning in Context) as mentioned on the Description of courses (1995-1997) is to help prospective teachers understand :

> "Role of social context and sociocultural background in learning. Natural and socially constructed differences among learners. Relationship among subject-specific knowledge, teaching and learning that subject, and the institutional and communal context. Multiple literacies"

The course goals for TE 401 & TE 402 were included on the course syllabus (Fall, 1993), by the instructors stated:

> "Next Fall at this time you will be preparing to take over the science classes of your own. You will be responsible for the well being and learning of the students in those classes. Our goal for this course and for TE 402 is to prepare you for those responsibilities. No one will expect you to be an accomplished professional--that will take years--but we hope that you will be a "well-started beginner," prepared to learn from your experiences as an intern and from your work other interns, cooperating teachers, and members of the NGU faculty. There is a lot you will have to learn to become a well-started beginner."

TE 501 & TE 502 are the fall and spring components of a year long seminar where interns from a school or group of schools share concerns and strategies related to the contexts in which they teach. TE 501 and TE 502 included all secondary interns in the school or small set of schools. The goals of these courses varied considerably by instructor, more so than in the other internship year courses. Generally, the goals were to offer support related to general concerns about teaching and to bring interns together to share strategies related to those concerns. This course has recently been changed significantly in structure.

The major goal for TE 802 & TE 804 is to continue to help prospective secondary science teachers develop as an effective classroom teacher and prepare them to seek and obtain a job in this profession. There are many goals shared with TE 501 and TE 502.

5. Course Objectives

General speaking, the objectives for TE courses are much more ambiguous, but it is clear that they differ vastly in purpose from science courses, science courses are content oriented, while TE courses vary in purposes. In general, the objectives of science teacher education courses were addressed by Jeff. He responded to the Preservice Program Interview-Teacher Education Faculty Form (1996) by using the Coding Scheme for Teacher Education Faculty Interviews and Course Syllabi (for more information see Salish instrument Package & User's guide, 1997). Jeff addressed most of the objectives for TE classes. He coded his beliefs for TE courses objectives as follows:

- Teacher as a reflective practitioner.
- Teaching as a profession by sharing ideas, by discussing content relevant to teaching, teacher organizations, professional issues (e.g., education reform, standards, legal issues, etc.)
- Psychology of teaching and learning especially conceptual and constructivist teaching.
- Testing, evaluation, and assessment in service to teaching and learning.
- Creating a constructivist learning environment.
- Instructional design, e.g., lesson /or unit planning.
- Nature of science as developmental inquiry.
- Computer applications in science teaching.

Steve shares his beliefs with Jeff that education is a profession, "I think a lot of the time they meant to sell to us or give us the idea that education was a profession and not just a, you know, some job that had good benefits." Terry believes that diversity, and teaching science for all students are the most common objectives for TE classes.

6. Instructional Strategies

In TE classes many instructional strategies were used, especially in the methods courses. Instructors and students reported that they used lectures, group work, cooperative learning, problem solving, discussion, projects, observations, videotapes analysis, hands-on, labs, modeling, & technology-based.

7. Instructional Resources

In science education courses many instructional resources were used such as State Essential Goals & Objectives, National Science Education Standards (NRC, 1996), Project 2061 Benchmarks, internet, readings, lab manuals, textbooks, audio-visual, computer software, course packets, & field experience guides. While, in the science courses Terry and Steve reported that they used only a few resources like textbooks, lab manuals, and computer software.

8. Methods of Assessment

The evaluation methods used in science education program varied. Jeff and Jack used the following evaluation methods in their teaching: field assignments, portfolio, reports, papers, working labs, essay exams, oral exams, home works, performance, presentations, actual teaching, projects, lessons/unit plans, journals, & interviews. Steve and Terry reported that they only experienced papers, interviews, and projects in their science education program. On the other hand, they mostly experienced multiple choice tests and lab reports in their science content courses.

9. Cooperative Learning

Teacher education faculty and prospective secondary science teachers agreed that cooperative learning and small group work were the most common instructional strategies in education courses. Terry indicated that they experienced cooperative learning, "More often in my methods classes than my general classes. Every methods class had at least part of the time in groups to model group work." In contrast, both of them only rarely experienced cooperative learning in science content courses. They had this experience sometimes in the labs (i.e., lab partners).

10. Research Experience

Neither prospective secondary science teachers nor faculty at science education program mentioned that they used actual student research in science education classes, except Jeff who was just beginning to use this approach in his teaching. Instead, all of them agreed that they did a lot of individual projects and/ or small group works in the science education classes, especially in the methods courses.

11. The Internship

It is a one year internship. Prospective secondary science teachers are required to go out to the field and teach for one year. The internship is both part of separate course and incorporated into existing courses. Throughout the internship, students stay in one placement, selected by the university, but with interviews between intern and collaborating teacher. Collaborating teachers are sometimes screened.

12. Field Experiences

Terry and Steve valued their field experience. They appreciated the science related TE courses because they were the first courses that provided opportunities to teach the material they intended to teach. Teaching was mentioned as an important tool that helped new secondary science teachers grasped the skills and habits of mind to become an effective science classroom teacher.

Prospective secondary science teachers acquired valued experience on teaching through their science education program. In TE 401 they had a chance to observe teaching inside a real classroom. They had the opportunity to teach one unit in science in TE402. In TE 501 & TE502, the internship year, they started to practice teaching extensively with the help of mentor teacher. In TE 802 & TE 804, they did most of the responsibilities of a teacher, but they were still prospective science teachers. They were responsible to their own classes. I n this program prospective secondary science teachers accumulated many classroom teaching experiences before they started their formal job as a science teacher.

13. Supervision

The goal of supervision in teacher education program was to support prospective secondary science teachers with a feedback about their student teaching. Usually, mentor teachers and field instructors were responsible to supervise them. The nature and process of supervision were described in Terry's response to a question on this matter, as she says:

> "I did my internship for one year at Elvira High School. I taught 4 biology classes and co taught a Chemistry class. I was supervised every other week by either a content area person or a general person. After supervision we discussed my teaching and possible ways to improve my methods. We also discussed areas in which I had improved or did well" (NTI, 1996).

Steve was supervised by Jack, a full professor, (instructor for many science methods courses) and field instructor, as he says:

> "Let's see. There's a field experience, I think Jack was kind of in charge of that, but I don't know if that was really evaluated at all. I think of the one who graded my papers that I wrote about the field experience, basically, ha, ha. And then my internship year, my field instructor was Bonnie" (NTI, 1996).

14. Important Experiences

Terry and Steve recognized their TE courses that related to science (science methods) as important experiences because courses were designed to help them how to teach. The internship was also regarded as an important experience.

Both of them mentioned that their field experience and internship stand in their mind as important experiences. Terry describes this experience as:

> "The most useful part of my TE experiences were the classes taught with my cooperating teacher. She was an inspiration for me from the start. *Having the ideas and insights of a current classroom teacher was by far the most important and influential part of my experience*" (NTI, 1996). [emphasis added]

Also, Steve agreed with Terry that it is helpful to learn from teacher education experiences and having a chance to talk to other science teachers, as he says:

> "I'd say the field experience and the internship, I can't remember the numbers now, what course numbers they were, um, some of the classes that we took right along with our internship, um, the eight-o-whatever, um, some of those were helpful. At times it was a little bit taxing because we were trying to figure out how to be teachers and at that point we weren't too happy about it, I mean, to write a paper or do a project or do a test with a grade or something like that. But, some of them were helpful but, mostly they tried to give us a clue of what teaching would be like outside of the classroom and like, uh, you know, what you're going to have to do at staff meetings and, you know, education things outside of the classroom....science related classes that we had, um, let us kind of, and *the most supportive thing there, I think, was that we got to talk to other science teachers maybe our age or our internship level or other experienced teachers, just to talk about things and share ideas and share information. Those were helpful for that,* I mean, that was good" (NTI, 1996). [emphasis added]

The importance of these courses comes from their content. In these courses, instructors used Wilson's, Shulman's, and Richet's (1987) terminology, who describe teaching as a cyclical process involving five steps: comprehension; transformation; instruction; evaluation; & reflection. In order to master teaching, new secondary science teachers need to be engaged in these dynamic cycle activities.

The first activity, comprehension, which will help new secondary science teachers understand the content that they need for the purpose of teaching which is deeper and more complex than just having specific subject matter knowledge.

The second activity, transformation, which will help new secondary science teachers transform the content into forms that will make it understandable, interesting, and meaningful for their students.

The third activity, instruction, which will help new secondary science teachers promote their students' understanding by using different instructional strategies.

The fourth activity, evaluation, will help new secondary science teachers use different ways to assess their students' understanding.

Finally, reflection will help them learn from their experiences. Learning from experience depends on the reflection that they do before, during, and after teaching. If they do it well, reflection leads to new comprehension, and they start a new cycle again. So, according to this perspective, learning from experience is a dynamic and continuous process.

These courses were designed to help new secondary science teachers to widen their understanding to the science content for the purpose of teaching. Jack and his colleagues set up the course in a way that would help them acquire specific teaching strategies within a science discipline, as he says:

> "The ways the class was set up, um, you know, we had the field instructors coming in and so um, the first half hour of class we would meet in small groups

> with the field instructors leading the small groups and, uh, then we switched over to, uh, we had a set of subject matter groups and so, like, I worked with the, uh, people who were teaching chemistry and physical science and, uh, you know that was about a third. The other two thirds were about biology and . Um, and *within the subject matter groups, um, we would talk about specific strategies and things like that, within the small groups we talked about specific strategies*" (Preservice Program Interview-Teacher Education Faculty Form, 1996). [emphasis added]

Jack believes that his students' subject matter deficit comes because they do not have, "really excellent teaching." He means that teaching in their science disciplinary departments is not adequate. Furthermore, he thinks that:

> "*Teaching is just really different from taking courses*, even if they're well taught courses and so this problem of transforming their subject matter knowledge is not going to go away regardless of how much we improve the, uh, curriculum in the colleges. There's no doubt that some of the deficiencies in the curriculum make it worse, but um, I 'd think probably the way they make it worse is, uh, leaving them kind of totally puzzled about why we would even ask them to do this, uh, as opposed to recognizing the importance of being able to do this and not knowing how. I'd say if we did a better job they would be in that latter position, *they'd recognize why it's important to do this and to know how.* And this that, turned out to be our focus on negotiation was writing objectives and a form, using form, some form of "describe, explain, predict, control" and then some piece of the real world. And, you know, they would say, "I want them to explain photosynthesis" and go through this thing and, well, photosynthesis is a theoretical construct and so, uh, use the concept of photosynthesis to explain X. what in the world is it that photosynthesis explains, or helps you describe, predict, design, whatever. And, uh that was a very important thing that they got better at over time and I think our insistence that a decent unit had to have some objectives of that form, um, was something that I would definitely do over again. It is productive, although they resisted terribly" (Preservice Program Interview-Teacher Education Faculty Form, 1996). [emphasis added]

As a result of subject matter deficit, prospective secondary science teachers would not be able to move from the comprehension level to the reflecting and constructing levels according to the state objectives. Jack elaborated more in this issue, and he adds that:

> "The way in which we engaged it was, um, requiring them to write objectives for their unit who were in the general form of the state objectives and which, uh, and the general form there is, uh, a verb, which is some form of "describe, explain, predict, control," and we found, the state objectives are divided into using "using, reflecting, constructing." Um, with this particular group, we really never got past the "using." We would keep reminding them that they ought to be thinking about reflecting and constructing *but they never got to the point where they had the mental space to do that"* (Preservice Program Interview-Teacher Education Faculty Form, 1996). [emphasis added]

Even science discipline majors lack understanding to the big ideas in their disciplines (i.e., chemistry). This was confirmed by Jean, as she says:

> "This is not my program, but my dissatisfaction comes from working with chemistry majors who choose to become secondary science teachers. They are true chemistry majors with high grades, but their understanding often lacks a big picture, an understanding of the big ideas" (Preservice Program Interview-Science Faculty Form, 1996). [emphasis added]

15. Student-Faculty Relationships

New secondary science teachers and their faculty agreed that they have an informal relationship (i.e., personal). Steve says in the TE program "people knew each other well enough." Terry also confirms that, as she says: "We were on a first name basis and had open communication."

16. Professional Linkages

In teacher education program professional linkages are required and encouraged. Prospective secondary science teachers were encouraged to have a membership in State Science Teacher Association, NSTA, and other content area organizations. For example, some prospective teachers are members in National Association of Biology Teachers (NABT). Jack in his class organized a session for them to present at the State Science Teachers' Association annual conference and encouraged all of them to go. Steve is a member of NSTA and State Science Teachers' Association. Terry is a member of NABT and State Science Teachers' Association.

17. Program Structure/ Teacher education Cohort

While cohorts do formally exist in TE, they are not seen as useful, functional or purposeful. The cohorts are formal, but weak. Steve described the feeling of most prospective secondary teachers when he asked, if he was a member of a student cohort, he said yes, "but I did not know really what the whole idea between team one, team two, and team three was." Also, Jeff's perception of TE program coherence was, "not too strong, but getting better."

18. Program Relationships

Both faculty groups from the TE department and the College of Arts and Science admitted that the nature of the relationships between the faculty members on those two programs (teacher education program and science content program) are informal, Diane said: "it's very informal." Furthermore, she thinks that Jean and other faculty members at TE department are, " a great bridge between the two groups." Since Terry and Steve completed their programs, some new structures have been developed to improve communication and collaboration among faculty in the two colleges. While ties have strengthened, there is much more work to be done.

Jean believes that the number of students in her chemistry class and diversity are big obstacles to reform. On the other hand, Jack sees that a close coordination between the two programs will not be able to happen, as he says:

> "I think in a university the size of North Global, um, you could hope to engender more of a culture of teaching environment at the subject matter departments but I think the idea that there would ever be close coordination between two large

departments like chemistry or biology and teacher education, um, *it's hopeless. It's just never going to happen*" (Preservice Program Interview-Teacher Education Faculty Form, 1996). [emphasis added]

19. Prior Career Influences

Neither Terry nor Steve had prior career experiences.

20. Philosophy of Teaching

Jeff in his coding interview addressed most of the philosophy of teaching science in teacher education program at NGU. His view about the philosophy of teacher education program includes that secondary school students should be provided with opportunities designed for them to construct their own knowledge, with teachers acting as reflective practitioners who empower students as learners. Learning is recognized as an interactive process while teaching involves interactive decision making. And that, "less is more," knowledge is a tool, not an end in itself. Diversity is valuable. Teachers should stimulate thinking on the nature of science, and while content transmission is part of a teacher's job, it is only a small part. Teaching is a profession. Learning should be relevant to the students. Assessment should be used to guide and modify instruction. The broad scope of this philosophy may be confusing to teacher candidates as no singular philosophy of teaching emerges from the NTI. Hands-on learning and using a variety of ways to teach are often mentioned. However, the philosophy of teaching in teacher education program is consistent with the contemporary reform agenda expressed in National Science Education Standards (NCR, 1996) and Project 2061 (1996).

Section two: Terry's Case Study

Terry Wheaton (a pseudonym) is a second year secondary science teacher in her early twenties. She earned her degree from North Global University (also a pseudonym) in 1994, which is one of the biggest research universities in the United States. She was a biology major and chemistry minor. Her areas of teaching certification are biology and chemistry.

Terry had about 15 hours of field experience at the middle /junior high school level, and about 90 hours at the high school level before she began student teaching. Her student teaching assignment was two biology and two chemistry classes at the high school level (grades 9-12).

Background

During her preservice education (teacher certification course work), Terry took courses in biology, chemistry, social science, and language arts. Her chemistry training and experience was one year-inorganic chemistry, one year-organic chemistry, one semester-physical chemistry, and two years-chemistry lab (organic and inorganic).

Terry's background in math and physics was math through calculus (3 years) and one year of introductory physics with lab.

Her science-specific training in teacher education was two years of science methods courses and the internship year which included science methods courses and science methods practical experience in the classroom. Terry's training in general education was three years of general education courses and the internship included seminars and practical experience.

Teaching Context

She began teaching at Target High School (also a pseudonym) in 1995. This was also the school where she student taught. Terry taught 9th grade students global science for two hours during the day and then taught to the lower track students what was called "Problem Solving Through Science" after school for three hours. She worked in a program for at risk students, virtually all of whom could be classified as having special needs. This created a situation where Terry taught the most difficult students in a difficult school.

Her school was in an inner-city of population more than 100,000, which includes low income families and area with high level of crime and drug use. 22% of the families earned less than $15,000/year; 33% of the families earned between $15,001 and $34,999; 38% earned between $35,000 and $74,999; 4% earned $75,000 and $99,999 and 2% earned more than $100,000. There were approximately 1700 students in the 9-12 high school she works in, one of four public high schools in the city.

She had several ESL (English as a second language) students. The gender and ethnic make-up of her classes was not filled in SIDESTEP questionnaire, but her classes were quite diverse. In this questionnaire, she reported that she addressed gender equity through equal treatment of boys and girls, equal use of male and female names in assignments, and by studying famous female scientists. Her videotaped lessons indicated that she treated them equally. For example, she assigned both boys and girls to activities in the videotape lessons.

Like many new science teachers, Terry did not know the science budget (e.g., lab equipment, textbooks, duplication, and media and software) for her school. This information would help new teachers to include more resources in their unit and lesson plans to teach for conceptual understanding.

In her classroom, Terry had one computer, but she did not have access to a computer lab. She had access to laser disc players, CD-ROMs, and a modem.

Like most other new teachers, beside teaching, Terry served as advisor to extracurricular activities. She was a Science Olympiad coach and she was active in the area high school rowing club. She spent approximately 15 hours per week preparing to teach science.

Terry attended two state, regional or national science teacher conferences. She presented at both of these conferences. She is a member of NBTA and State Science Teachers' Association.

In her questionnaire, Terry listed the following methods of assessment of student understanding: group work, worksheets, discussion, essay/short answer, projects, oral reports, homework, concept maps, multiple choice tests, quizzes from the curriculum, lab write-ups, and participation.

Terry's Knowledge and Beliefs

Terry's knowledge and beliefs were documented by using Teachers' Pedagogical Philosophy Interview (TPPI). Her interview was audio taped, transcribed, coded, and analyzed. HyperRESEARCH software was used in the process of coding and analysis. Most of Terry's knowledge and beliefs were coded as early constructivist in nature with some aspects of didactic, conceptual, and experienced constructivist teaching. The summary of the analysis process of her knowledge and beliefs is included in Table 5.

Table 5: Analysis of Terry's Knowledge and Beliefs

Area/ Knowledge & Beliefs	Didactic	Transitional	Conceptual	Early constructivist	Experienced Constructivist	Constructivist Inquiry
Teacher's view of Content	XX	X		X		
Self as a Teacher	X			XX*		
Teacher's Actions	X	X		XX	X	
Students' Actions		X	X	XX		
Environment				X		
Context				X		
Diversity	X			XX		
Philosophy of Teaching	X		X	X		

*XX means that the teacher's knowledge and beliefs in this domain are more dominant than X. For example, Terry's view of herself as a teacher is mostly early constructivist with some didactic aspect (X). No mark in a category means that Kathy did not indicate any aspect of knowledge and beliefs about herself in that category.

Terry 's View of Content

The coded interview indicates that Terry's views of teaching science content are mostly didactic with some aspect of transitional and early constructivist.

In her questionnaire (SIDESTEP, 1996), Terry listed the top three goals in order of importance that she holds for her students are:

- "To gain confidence that they can succeed in learning science."
- "To see science as a way of thinking applicable to everyday."
- "To learn how to write in creative ways to solve problems."

She believes that facts in science are bits of information that are true. Also, she believes that laws are rules and regulations that always hold, while theories are not really laws because they are not proven yet.

Terry views science as a way of inquiring about the world by using a defined method. Her views of science reflect that as she says:

> "*Science to me is uh, basically inquiry into the world around you*, trying to figure things out around you, and doing it in a method that can be, in a way that other people can repeat what you've done and doing it in the like, you know, going through a method where you have a question and you try and figure out the answer and then you decide from that answer where to go next. *Basically trying to figure out the world around you through a defined method"* (TPPI Interview, 1996). [emphasis added]

For Terry, science is a method to discover the world (i.e., understanding the world by using the scientific method) not as inquiry-oriented that helps students construct their understanding and make sense of the real world.

She values problem solving in science and values the use of science to approach environmental problems. "I guess my biggest thing is for them to know that they have an effect on the world around them and that the world around them also affects them and their quality of life." She also believes in the usefulness of science, and she values the effectiveness of science to solve real problem.

Self as a teacher

The coded interview indicates that Terry's view of herself as a teacher is mostly that of an early constructivist with some didactic aspects.

She wants to work more on her discipline and classroom management.

> "W*hat happens is that other kids suffer, or they don't learn as much* because, you know, what's-his-face is climbing off the walls, and so I've got to kind of learn how to deal with that. But it's really hard for me cause it conflicts with a lot of things that I think are important as a teacher, and that's making everyone feel good about being there" (TPPI Interview, 1996). [emphasis added]

According to the TPPI Super Codes, these teaching beliefs would place her in the didactic domain in terms of her knowledge and beliefs. But I do not think that a teacher who worries about her kids misbehaving makes her a didactic teacher. Such beliefs are not particularly telling as to whether the teacher is didactic, conceptual or constructivist. This quotation is telling about who Terry is as a teacher, but it does not directly correspond to the primary set of labels used in this study.

She believes that her main strengths are self-attributes. She believes she has a positive impact on her students. Also, she believes that it is important to know her students and their learning needs. In the TPPI (1996) interview she said the following about her main strengths:

> "I'm pretty positive. And that's, um, something I work at, too. But that's, like, my main thing that I try and get across to the kids is that, you know, we're all going to be here everyday. We might as well enjoy the time while we're here."

Also, Terry cares a lot about her students. In the TPPI (1996) interview, she says:

> *"I care a lot about the kids, and my main reason to be there is for them.* And, um, the goals that I have are mainly to see how many kids that I can get to be successful in my classroom, and that's kind of what I work towards. And I try to be fair, I try to be...still keep things under control anyway, but sometimes I think I'm a little bit too nice which is what one of my kids said to me the other day. Made me think about it, but...My main thing, though, is just, I mean I, every time I want to see how many kids can I get to pass my class because I, it just drives me crazy to see a list where I've got all these E's at the bottom of it, you know. When I do the little shuffle on my grades, put it in order by grade, Oh my God!" [emphasis added]

Her view of a well organized classroom is one that, "runs without me... my favorite thing is when I can sit there and look and see kids working together on stuff that they're supposed to be working on" (TPPI, 1996).

These statements show that Terry cares about her students' learning and wants them to be successful in their learning, she has positive feedback on them, and she wants her classroom to be run smoothly with students taking responsibility for the classroom environment.

Teacher's Actions

The coded interview indicates that Terry's actions are didactic, transitional, early constructivist, and experienced constructivist. But her knowledge and beliefs about her actions in side the classroom suggest that her teaching style is predominantly that of an early constructivist.

Terry likes certain aspects of the state mandated curriculum, but also has considerable freedom in determining what to teach. Mainly, she decides what to teach and what not to teach based on the state objectives book and school district objectives. According to the TPPI super codes, these teaching beliefs would place her in the didactic domain. But, in fact she does not want to follow these objectives as a mandated curriculum, she wants to follow them in order to improve her students' achievement in the proficiency test. Mainly, this test is designed to assess students' conceptual understanding in science. Based on that, her teaching beliefs suggest her an early constructivist teacher, because she wants to direct her teaching toward students' understanding, as she says:

> "*Well, the [state objectives] book would probably be the biggest one*. That definitely influences the way I teach cause I use their objectives, *I know my kids are going to have to take that high school proficiency test"* (TPPI, 1996). [emphasis added]

When Terry was asked, "In what ways do manipulate the educational environment to maximize students understanding," she said she manipulates both the physical and emotional environment. The physical environment is manipulated by moving desks so that they face each other rather than the front of the room. The emotional environment is manipulated by creating a comfortable environment and "...make them feel good about being there and wanting to be there and not dragging every day going 'Oh, I hate it. I hate this class!'"

Terry recognizes that students without motivation to learn and taking responsibility about their learning inside the classroom are impediments for her teaching the way she would like to teach. She attempts to overcome these constraints by praising and rewarding students for doing their work by,

> "...just going around and saying, you know, 'Look at you, doing all your work. That's great! And trying to say it loud enough so that the person next to him can hear and so they'll say 'Hey, Miss Wheaton, I'm doing my work, too" (TPPI Interview, 1996).

If she believes students do not understand, she will not move onto the next concept, "I try not to move on if there's too many kids that really don't know what I'm wanting them to know." She uses students' understanding as criteria to move from one concept to another (i.e., her teaching decisions are based on students' understanding).

Students' Actions

The coded interview indicates that Terry's students' actions range from transitional to early constructivist. Also, the most dominant teaching knowledge and beliefs about her students' actions are early constructivist.

She said, "...all my kids have special needs," but she has not determined how best to address these special needs. The only way that she deals with it is by, "trying to do different ways of getting things...across to her students." Terry uses different ways to accommodate students with special needs. However, it is not explicit whether she wants to make changes in curriculum covered, instructional strategies, or in her expectations.

Terry believes students can demonstrate their learning when they can answer a question, be able to explain the material to other students and through social interactions, or make applications. One of these ways of students understanding were mentioned when she described how learning has occurred in her classroom, she said:

> "I can think of one instance this year that was really cool. *I had a project that they had to do where they had to make a carnival energy game and they had to show energy transformations in the game that they made,* and there were all different ones. But one of them that they made was the one where they have to do that coordination thing...Jenny did it, too. You put this wire and you hook it up to battery so that you complete the circuit with the one in your hand and you have to go around it without touching it or a light bulb lights. And I had these two girls working on it and they were, like, they were kind of frustrated with it and they had trouble with it. But then, like, they got it all done and, um, *they finally got it to work,* you know, they finally got the light bulb to light. And I really didn't show them how to do it exactly, and they were like "We did it Miss Wheaton!",

> you know, ha, ha. And, like, that was really cool cause *they were excited about it and I think when a kid gets excited about that, that's some thing that, you know, they did that they didn't think they could do, which means to me that they learned something that they didn't know before*" (TPPI Interview, 1996). [emphasis added]

She also believes that her students learn best in a variety of ways, including listening, group work, and hands-on activities. She emphasizes the importance of using different teaching strategies, as she says:

> "For everybody to get all around different ways of getting information and learning about stuff, but also because some kids are just better at different things. *Some kids are really good at learning about things just by hearing them.* And I don't know why, but some kids need that. But *other kids are really good at working with students and groups, so...I like variety"* (TPPI Interview, 1996). [emphasis added]

All these teaching beliefs would reflect her being an early constructivist teacher in terms of her knowledge and beliefs about students' actions, because she emphasizes the need to attend to students' diverse ways of learning (i.e., individual learning, hands-on, groups work).

Environment

Terry believes students like her class because of the teaching methods she uses and the students in her class are active learners. She cites one of her student's explanation of the class:

> "...on the first day [of the second semester] this one kid said, you know, 'What do we do in here? What do we do in here?' And this kid who had me last marking period was like 'We're always doing stuff in here!' He was like 'We're going to be up doing...we're going to be up at those back tables all the time doing stuff!"

These teaching beliefs suggest that her classroom environment is student-centered, because she believes that students should be active learners, and she emphasis her ability to use different teaching methods (i.e., hands-on, work in groups) that engage them in meaningful task. For example, in the videotaped lessons, Terry's students worked in groups to design commercials about energy transformations and applications.

Context

Terry recognizes the lack of student motivation and responsibility as impediments to her teaching in the way she would like to. She thinks strongly that some of her students' behaviors, especially high rates of absenteeism would affect her teaching as she says:

> "*kids not showing up is so irritating*. Because what I would like to be able to do, um, is have the kids work with the same people every day, and be able to go back to what we did yesterday every day, and *that is just so frustrating* when they don't come. Um, that's probably one that really bothers me. And *the other ones is sometimes is just motivation*. Like, trying to get the kids to want to do that stuff. And *I can, like, break my back trying to figure out something interesting and fun to do and sometimes it just, you know, doesn't work. Sometimes it does work and it goes great,* but, you know. My seventh hour it's pretty hard. Those guys have had a long day. And to get them really fired up about something is not always easy. So that's kind of an impediment, probably, is that. And then, like, um, there's kind of a feeling, I think, right now, that students have that is very passive. Um, like I said, there'll be kids that'll show up with nothing, just themselves. Like, you know, "Do it to me," you know, ha, ha. Just, somehow, *"Learn me the stuff," like I'm going to just throw it in their head or something,* ha, ha" (TPPI Interview, 1996). [emphasis added]

Terry recognizes that students' motivations and acceptance of responsibilities are essential for students to learn. She recognizes that she needs to help her students to be self motivated to involve them in the learning tasks.

Diversity

Again, Terry recognizes that, "...all my kids have special needs." She is trying to determine how to address these needs, but does not feel she is meeting them. "But I really don't do anything so different for them, yet. I have to go to an IEPC [Individual

Education Plan Committee] meeting next week so maybe I'll answer that question differently in the future." Failure to address the needs of these students indicates that she may be didactic in addressing diversity, or she just not know how to, however, recognition and forward thinking may indicate that she is moving away from a didactic position to an early constructivist.

Careful reading of her TPPI transcript indicate that Terry has a strong tendency toward constructivist views about her classroom diversity because she is actively seeking ways that will help her to deal with students with special needs. Her awareness about her students learning suggests the beliefs of an early constructivist teacher.

Philosophy of Teaching

The coded interview indicates that Terry's philosophy of teaching includes aspects of conceptual and early constructivist teaching models.

She believes that a good learner can come to class with a pencil and a notebook. Terry works hard to convince all her students to come to class with these basic requirements. These may sound like a minimal expectations, but it is important to remember that she deals primarily with a very high risk population of students, many of whom have already dropped out and have re-enrolled to be in her class. Without first meeting these minimal expectations, it is virtually impossible to exceed them.

Terry states several times that students demonstrate what they have learned or that they understand a concept, "...when they can explain it to somebody else." She also believes this about her own understanding. Terry values science as a way to solve problems and she wants her students to understand this as well,

> "As far as science goes, I mean, the main thing I want them to know is that it's a way of solving problems, and that they can use that way of solving problems all the time" (TPPI, 1996).

For Terry, science is as a way to solve problems (i.e., science connects to the real world as a way to go about solving problems).

Terry recognizes that she and her students learn in a variety of ways, (see source material in students' actions section), "but my favorite way to do it [learn] is just to ask other people." Her interview makes repeated references to asking questions and discussing as ways that she learns best. Six different citations are coded where she mentions these methods of learning as important or useful.

She believes her teaching can be important in students' lives, that, "having positive experiences in my classroom carry over to how they feel about, you know, themselves and how successful they can be," and her ultimate goals in her teaching are expressed when she says,

> "The founding principle for me that underlies everything is trying to make kids feel good about science, and them doing science, and them being students, and I mean, ultimately, them being good people" (TPPI, 1996).

Clearly, the self-esteem of her students is important. This kind of teaching belief would place her knowledge and beliefs about philosophy of teaching in the early constructivist domain, because the center of her philosophy of teaching is students. She wants them to be good learners. Moreover, she wants her students to be good citizens.

Terry's Teaching Performance

During the three consecutive days that Terry was taped, she taught "Transformations and Applications of Energy" to 9th grade students at Target High School. In the first lesson she explained to the students the instructions of how to design commercials about energy transformations and applications and what things should be included in their commercials. After that students worked in groups of two or three from the second half of the first lesson through the first half of the third lesson. On the last half of the third lesson, students presented their works as a group to their classmates. During the groups' work, Terry was moving from one table to another to answer students' questions or explain instructions to them.

These three consecutive videotaped lessons were analyzed by using Secondary Teacher Analysis Matrix-Science Version (STAM). The STAM analysis of the video portfolio for Terry's teaching performance is reported under several subtitles that include: overview; teacher's content; teacher's actions; students' actions; resources; environment; and other, (for more information about the categorization of Terry's teaching performance see Table 6.

Overview

The characterization of Terry's teaching performance is very difficult because of the lack of students' engagement in the classroom activities. The majority of her teaching performance lies in the didactic and transitional domains, with some exceptions in the early constructivist domain (i.e., students' actions, teachers' method, decision making, and students' work displayed). Most of the teaching time was spent in attempting to control the class. Her difficulty in managing the class influenced her teaching. Her

Table 6: Video Portfolio Analysis of Teaching Performance for Terry

Area/ Teaching Style	Didactic	Transitional	Conceptual	Early Constructivist	experienced Constructivist	Inquiry Constructivist
Teacher's Content	XX	X				
Teacher 's Actions	XX	X		X		
Students' Actions	X	X		XX		
Resources	XX	X		X		
Environment	X			X		

students' behaviors, as she mentioned on the TPPI (1996) interview, were irritating and clearly affected her teaching. So, her students' behaviors were one of the limitations of this study that influenced the analysis of her teaching performance.

Teacher's Content

Terry asked her students to create a commercial for energy transformations and its applications. She gave them the instructions and explained what should be included on that commercial. The commercial components were determined by Terry. She told the students that the commercial should cover the following issues: energy source; applications; information about this source of energy; damages, advantages, and disadvantages; safe instructions; how it works; and whether this source is renewable or not. She told her students that she was going to offer extra articles and books to support them with more information about this topic.

Most of the content was presented by students, and tended to be descriptive. In a few activities, examples and connections were integrated with the subject matter of science. In one activity, students and teacher offered examples for energy sources (e.g., gas, water, trees, etc.). Also, in the commercial activity, students offered some examples in their presentations. There were no exceptions because there were no explanations, just some description from a very general prospective. No explicit mention was made of the process or the history of science.

Teacher's Actions

She used some student-centered methods in her teaching (working in groups, group presentations, etc.). Labs, demonstrations, or hands-on were absent from her teaching on these three days. Terry had little interaction about subject matter with her students. Terry's questions were not directed toward scientific knowledge, nor factual information, most of the time was directed toward discipline. When she circulated to the groups, Terry tried to clarify procedural issues to her students.

She used tests, quizzes, and journals to assess her students' understanding. But, the video did not show how she used the assessment information. Occasionally, she used assessment to check her students' scientific knowledge (for example, she was looking for valid scientific knowledge). It was clear from group presentations that Terry accepted all students' ideas about subject matter. However, she did not raise any questions after each group presentation to push or stimulate her students thinking.

Students' Actions

Students in Terry's class used some representation of ideas like displays (in their commercials) and journals, some of them were reconfigurations of textbook information, few were their own contributions. Mostly, students' question focused on clarifying procedures. Some questions asked for clarification of terminology or repeat of information. Student-student interactions about subject matter were hard to observe because of the sound quality on the tape. Based on the students' group presentations, I can speculate that there were some student-student interaction about procedure and some about understanding. Although students did not initiate any activity, they volunteered a few examples about energy applications, but connections to class activities were weak. Usually, students ignored teacher's procedures and showed confusion over procedure because they were worried about social problems rather than academic problems related to content.

Resources

Few resources were used such as journal and textbook. Also, she provided some resources (i.e., articles and books) to support her students with more information that would need in producing their commercials. Resources were related to the production of commercial on transformations of energy and its applications. Mainly, these resources were controlled by Terry. Most of Terry's students were involved in the process of videotaping through the three lessons. She assigned a student every ten-fifteen minutes for this task. However, this action showed a degree of trust between Terry and her students, but some students used this time to introduce his or her classmates to the camera. These events plus other disciplinary issues shifted students from being on-task.

Environment

The students in Terry's class had a role in making decision about how to record and design their commercial. Students used different ways to present their commercial. For example, some groups used poster presentation, one group used dialog format in the question/answer form, and another group told a story. Many decisions in this class were made by Terry. There were few teaching aids displayed which were not related to content (e.g. periodic table of the elements and skeleton), and some students' posters that some of them used in their group presentations. Jean one of Terry's teacher education instructors told me that Terry did not have her own classroom, she was moving from one class to another, and transporting her materials on a cart.

Other

The accuracy of content for Terry was largely unknown because she seldom offered direct instruction. The quality of student-teacher interactions was often cooperative, but mostly the focus of interaction was about procedure. Most of the time, students were off-task. Terry spent time getting her students back to work on their commercial. Much downtime was observed in her classroom. Transitions were poorly organized and were not naturally smooth. For example, she spent ten minutes to collect students' journals.

Terry was not lecturing or portraying science as a body of facts. She was teaching the most difficult students to teach in a high school plagued with discipline problems and high absenteeism. She chose this class to be videotaped because she had a lot of difficulties teaching science in this context. Choosing difficult classes did not appear to be the norm in the national sample, however. Also, she chose these physics subjects (energy transformations and applications) as a content for instruction, because she realized that her background in physics and chemistry were not so good. So, she attempted to have feedback from the Salish staff in order to improve her teaching in these two science areas within a difficult school context.

Summary of Terry's Case

Terry is a new secondary science teacher in her early twenties. She earned her degree from North Global University in 1994, which is one of the biggest research universities in the United States. She was a biology major and chemistry minor. Her areas of teaching certification are biology and chemistry.

She began teaching at Target High school in 1995. Terry taught 9th grade students global science for two hours during the day and then taught the lower track students what was called "Problem Solving Through Science" after school for three hours. She worked

Table 7: Summary of Analysis Results for Terry's Knowledge, Beliefs, and Performance

Area/ Knowledge, Beliefs, & Performance	Didactic	Transitional	Conceptual	Early Constructivist	Experienced Constructivist	Constructivist Inquiry
Teacher's Content	XX √√	X √		X		
Self as a Teacher	X			XX		
Teacher's Actions	X √√	X √		XX √	X	
Students' Actions	√	X √	X	XX √√		
Environment	√			X √		
Context	X			X		
Diversity	X			XX		
Philosophy of Teaching	X		X	X		

√ represents teacher's performance and X represents teacher's knowledge and beliefs. XX or √√ means that the teacher's knowledge/beliefs or performance in this domain are more dominant than X or √. No mark in a category means that the teacher does not hold any aspect of knowledge/beliefs or perform any style of teaching in that domain.

in a program for at risk students, virtually all of whom could be classified as having special needs. Terry spent much time in her classroom on motivating and guiding students to be involved on their learning tasks. It was clear from her videotaped lessons that she was more concerned about classroom discipline more than any thing else.

Terry provides evidence that she had inconsistency among her knowledge, beliefs, and performance. Most of Terry's knowledge and beliefs turn out to be student-centered in nature with some aspects of conceptual and teacher-centered. While, she displayed teacher-centered teaching performance, with some exceptions in the student-centered domain (students' actions, teachers' method, decision making, and students' work displayed). However, Terry did not display any conceptual teaching performance through her three videotaped lessons, except in one activity that related to the composition and formation of one of the energy sources, coal. Summary of the analysis results for Terry's knowledge, beliefs, and performance is included in Table 7.

Section Three: Steve's Case study

Steve Brook (a pseudonym) is a second year secondary science teacher in his early twenties. He earned his degree from North Global University (also a pseudonym), which is one of the largest research universities in the United States. He was a biology major and chemistry minor, and is certified to teach in both areas.

Steve had about 90 hours of field experience in a high school before he became an intern. During his internship, he taught half days in the first semester and full days in the second semester. His student teaching assignment was eight biology classes for high school level (9-12) in two semesters.

Data about his preservice education (teacher certification course work) is not accessible because, currently, he is teaching English as a second language in Japan, so he could not be interviewed through phone or e-mail. Steve and Terry[3] both graduated from North Global University in the same year, with the same major and minor, so it is likely that they share a lot of their preservice education program. They were in many of the same teacher education classes, and because the major and minor at NGU are clearly delineated it is quite likely they shared many of their science content courses.

Steve taught tenth grade biology and eleventh and twelfth grade chemistry.

Teaching context

He began teaching at Kroger High School (also a pseudonym) in 1995. His school was in a small town with a population 3,500. In this community 14% of the families earned less than $15,000/year; 39% of the families earned between $15,001 and $34,999; 43% earned between $35,000 and $74,999; 3% earned $75,000 and $99,999 and 1% earned more than $100,000. There are approximately 550 students in this 9-12 high school.

In his classes, Steve had 53 males (50 Caucasian and 3 Hispanic or Latino) and 57 females (55 Caucasian and 2 Hispanic or Latino). Regardless of their gender, Steve believed he treated all of his students with same respect. He said that, "he did not differentiate among them with grading and questioning" (SIDESTEP, 1996). His videotaped lessons confirmed that. For example, in the one lesson which included a demonstration experiment, he asked questions of boys and girls equally (2 boys and 2

[3] More information about Steve's preservice education can be found in the previous section of this chapter 3: Terry's Case Study.

girls) and he treated them with the same respect.

Out of 110 students, Steve had 10 students with special needs; none of them had English as a second language. Their needs were fulfilled by adapting assessment and teaching styles. He also developed a good rapport with the students' special education teacher.

Like many new science teachers, Steve did not know the science budget (for example, expendables, equipment, duplication, textbooks and other prints resources, and media and software) for his school. This kind of information would be considered essential for any science teacher, especially a new one, to figure out which resources are available that would fit with their plans and help them to teach for conceptual understanding.

In his classroom, Steve had no computers, but he had access to a computer lab once a semester, and limited access to laser disc players, CD-ROMs, and a modem.

Like most other new teachers, besides teaching, Steve had other non-teaching assignments. He was an athletic coach and class sponsor.

It is common that new teachers usually do not attend any professional conferences or belong to any professional organizations. But in Steve's case, he attended and presented at the state science teachers' association conference. Moreover, Steve is a member of NSTA and his state's Science Teacher Association.

Steve's Knowledge and Beliefs

Steve's knowledge and beliefs were documented by using the Teachers' Pedagogical Philosophy Interview (TPPI) developed by Salish. His interview was audio taped, transcribed, coded, and analyzed. HyperRESEARCH software was used in the process of coding and analysis in conjunction with codes and "supercodes" developed for the Salish Project. Most of Steve's knowledge and beliefs were coded as conceptual, early constructivist, and experienced constructivist teaching styles. He also holds some aspects of didactic and transitional knowledge and beliefs about teaching. The summary of the analysis results for Steve's knowledge and beliefs according to the TPPI supercodes[4] is included in Table 8.

Teacher's View of Content

The coded interview indicates that Steve's views of teaching science content are mostly early constructivist with few aspects of transitional.

In his questionnaire (SIDESTEP, 1996), Steve listed the top three goals in order of importance that he holds for his students:

- "To become problem-solvers."
- "To learn how science can affect their lives, positively and negatively."
- "To become active members in today's changing society."

He wants his students to view science as fun and something that they can relate to their lives. According to the TPPI super codes, these teaching beliefs would have classified him as transitional teacher. However, a careful reading of Steve's TPPI (1996) transcript would raise questions about this conclusion, because he wants his students to

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[4] TPPI super codes matrix is in Salish Instrument Package & User's Guide (1997, P. 64-66).

Table 8: Analysis of Steve's Knowledge and Beliefs

Area/ Knowledge & Beliefs	Didactic	Transitional	Conceptual	Early Constructivist	Experienced Constructivist	Constructivist Inquiry
Teacher's View of Content		X		XX*		
Self as a Teacher	X			XX		
Teacher's Actions	X	X		XX		
Students' Actions	X		XX	XX	X	
Environment	X			XX		
Context	X			XX		
Diversity			X			
Philosophy of Teaching	X		XX	XX	XX	

*XX means that the teacher's knowledge and beliefs in this domain are more dominant than X. For example, Steve's view of science content knowledge and beliefs are mostly early constructivist (XX) with some transitional aspects (X). No mark in a category means that Steve does not express any aspect of knowledge and beliefs about his content knowledge in that category.

make connections between what they learned in side the classroom and the real world. For example:

> "*Well a lot of what I do is to make science something that they can relate to*, at any rate, have a lot of ideas of science and things that are fun in the classroom, and I try to *bring it into my everyday life*, like the digestive system or something. You've all had digestive system failures, ha, ha. You know, what does that mean? Or, I try to just make it so that it can relate. And sometimes I have to stretch it a little bit, but, you know, I think if *they can relate it to something that goes on in everyday life*." [emphasis added]

So, for Steve one major goal of his teaching is to help students make connections between science and everyday life activities (i.e., application of scientific ideas to the real world).

Steve also believes that the most important science skill for his students to understand by the end of the school year is problem solving. He believes that problem solving is more important than content knowledge in either chemistry or biology. He explained, "It's probably more important that they can solve a problem than... [have certain] knowledge and skills."

He believes that he can learn science best by teaching. Steve believes that teaching helps him understand the content in depth, even the abstract concepts in chemistry, as he says:

> "I never have learned so much as when I had to teach something or talk to a group of students or a whole class about it, you know. It's just the easiest way to really, really get in depth. I mean, I never understood parts of chemistry before I actually taught it, and it's starting to make sense" (TPPI, 1996).

He considers students' engagement in subject matter and his students' ability to make decisions to be the underlying principles of his science goals. All these teaching beliefs provide evidence that he is an early constructivist teacher in terms of his knowledge and beliefs about science content. These basic principles of science teaching were mentioned in his TPPI (1996) transcript. He says:

> "...*engaging students in subject matter*. Um, providing an atmosphere where the students can, um, take a little responsibility upon themselves, learn how to be responsible people, um, and letting them get to the point in their life where they can make decisions for themselves which is one thing that I think a lot of students need to work on, you know. They're not to the point where they *can make decisions on their own, and I think that's one of the main points that I like to strive for*, I don't profess to even be close to it..." [emphasis added]

Therefore, regarding content, Steve provides some evidence of beliefs that represent transitional teaching (e.g., he wants his students to view science as fun) but the major emphasis of his beliefs is early constructivist. Most of his beliefs in this domain provide evidence that he holds an early constructivist teaching style (e.g., by connecting science to real life applications, students are able to make their own decisions based on their learning in science class; and to solve problems. By engaging students in subject matter, Steve helps students to become active members in the society.

Self as a teacher

The coded interview indicates that Steve sees himself as an early constructivist with some aspects of didactic teaching.

He wants to work more on his classroom management. Furthermore, he thinks that most teachers can improve their classrooms and teaching by working on management. According to the TPPI supercodes that concerned classroom management and time management, his responses are coded as didactic. However, these are, in fact, concerns of most teachers, and particularly of inexperienced teachers (Hall, 1979; Hall, et. al, 1991).

His view of a well-organized classroom is one that is,

> "...running well, I'd say that most, I wouldn't say all, but most of the students are engaged in an activity of some sort, um, you know. And I, I think sometimes engagement can be them paying attention to what's going on, whether it be me or another group presenting, but I think most of the time it's when they are *actually actively doing something in the classroom.* And that doesn't mean that it's quiet and it doesn't mean that it's um, there's not people running around doing things, it means they're all actively engaged, or most of them are actively engaged" (TPPI, 1996).

Steve wants his classroom "running well" not for the sake of controlling the classroom, but in fact, to have students actively engaged on their learning activities. According to the above, Steve sees himself as a facilitator inside the classroom (i.e., organizing activities for students to gain experience that will lead to learning. This form of teaching reflects "learning as a process" (Grunder, 1989), which would help students develop conceptual understanding.

Steve believes that one of his main strengths as a teacher is his ability to communicate with the students. Steve realizes that he has a positive effect on his students through feedback from students and other people, as he says:

> "*...feedback from students* and, um, you know, um, *feedback I get from other people who say I'm doing a good job*, that I've taught well, or if I've seen them in my class that day, give them my token, or he said , uh, you know that was a great lecture, it was a very interesting lecture" (TPPI, 1996). [emphasis added]

<u>Teacher's Actions</u>

The TPPI supercodes indicate that Steve's beliefs about teacher actions are diverse including aspects of didactic, transitional, and early constructivist teaching.

When he was asked, "How do you decide what to teach and what not to teach?" His response was with what he "felt comfortable with" in teaching the previous year (i.e., teaching biology during his internship). He says:

> "I really ended up gearing it towards things that I taught last year, because I was more comfortable. Now, I did a lot of applications, and I switched things around, *but as far as biology goes, I um, went with what I felt comfortable with*" (TPPI, 1996.) [emphasis added]

It is clear that Steve makes his decisions about what to teach based on his confidence on specific subject mater that he taught last year, not on "students'-learning". These beliefs focus on "content-learning" as an orientation to make decisions about teaching instead of on the integration between learning-content and students-learning to make these decisions (Anderson & et. al, 1998).

He believes that time is the only impediment that prevents him from implementing his model of teaching and learning inside the classroom, "I think it's just time. You can't talk to everyone, give everyone a one-on-one educational experience without more time." Again, these are concerns of many teachers, particularly inexperienced teachers. Consider his response for how he can overcome this constraint. He needs more time to know each individual in his classroom to give them individual educational experience, as he says:

> "Take as much time as I can to do that. I mean, I don't necessarily feel I do it enough, because there's just other things I have get done, but you know, I usually set aside a day during the marking period, you know, where *I talk to each kid individually about their grade, about their work, um, and then any other chance I get in the lab or, you know, working on projects* or something like that" (TPPI, 1996.). [emphasis added]

However, one could say, a didactic teacher needs more time to know his students. But in Steve's case, he needs more time to, "give everyone [students] a one-on-one educational experience." So he wants to use this time to assess students' understanding individually, in order to plan better and address students' misconceptions in lessons.

When he was asked, "In what ways do you manipulate the educational environment to maximize student understanding?" He said,

> "…change groups a lot.. I don't know...one day we've done a group activity, the next day we, I try to say, O.K., we'll go to an individual activity where they're working on groups, too, something *where they have a group project where they have to present the group to other students*, or something just to keep things changed up so they don't get into ruts too much. So I try to do that as much as possible" (TPPI, 1996). [emphasis added]

It is clear from this quote that Steve uses small groups as an instructional strategy in his teaching. Thus, students have a chance to work on a project within their groups and be able to present that project to their colleagues. His video taped lessons confirmed that he used small group techniques often in his teaching (i.e., students were able to gain knowledge through their own interaction, even though the nature of interaction was about how to solve mathematical problems). Steve wants to change classroom format (e.g., group project and presentations) in order to maximize student learning.

In his questionnaire (SIDESTEP, 1996), Steve lists the following methods of assessment of student understanding: group work, discussion, essay/short answer, projects, homework, concept maps, student-developed protocols, quizzes from the curriculum, and lab write-ups.

Therefore, regarding teaching actions, Steve provides some evidence of beliefs that represent didactic (e.g., time is a constraint) and transitional teaching (i.e., make teaching decisions based in what is comfortable to him). However, the major emphasis in his beliefs about teacher actions is early constructivist (e.g., he needs more time to know his students in order to offer individual educational experience).

Students' Actions

The coded interview indicates that Steve's students' actions are didactic, conceptual, early constructivist, and experienced constructivist.

Steve believes that his students can learn best by giving them the right answer to their questions, e.g., when student ask, "What's the answer to that question, Mr. Brook?" Usually, he gave them the right answer from the beginning. But often he forced them to think about it and come up with something. These teaching beliefs suggest that he holds some didactic beliefs in terms of knowledge and beliefs about his students' actions, but is also trying out alternatives for encouraging them to generate ideas.

He accommodates students with special needs in his classroom by changing expectations for students. Usually, Steve changes the testing format, e.g., "I do the best I can to [accommodate students with special needs], on quizzes, tests, writing assignments." Also, he works with the special education teacher for these students.

Steve believes that his students, "understand a concept if they are able to ask questions, explain, and connect concepts together." Furthermore, he believes that his students can understand a science concept through writing, as he says:

> "If they can write about it, if they can, um, *if they can go beyond just the rote memorization of something and put a concept together with another concept or put ideas* together, and usually that comes out in writing" (TPPI, 1996). [emphasis added]

Students are able to use different methods of representation (e.g., drawing, concepts map, essay, etc.) to show their conceptual understanding. Indeed, Steve did that three times in his videotaped lessons. He asked his students at the end of each lesson to write or draw a concept map for the most important chemical concepts that they learned in that lesson.

He believes that learning is occurring in his classroom from students' feedback, such as, when his students say to him that he is, "doing a good job." Also, he believes that he can maximize students' understanding by letting students work in groups. Steve wants his students to view science as a discipline related to their everyday lives (i.e., the real world).

Therefore, regarding students' actions, Steve holds few aspects of didactic (e.g., giving students the right answer direct without giving them a wait time to think about the answer) and experienced constructivist (i.e., using a variety of assessment methods). Most of his beliefs about students' actions would be scattered between conceptual (e.g., students be able to connect concepts together) and early constructivist (e.g., students work in groups, and students are able to make their own decisions[5]).

Environment

Steve believes his students like the class because of the knowledge they acquired through their learning science, and the importance of science to their lives. According to the TPPI supercodes these teaching beliefs would place him in the didactic domain. But a careful reading of his TPPI (1996) transcript would suggest he is an early constructivist teacher in terms of knowledge and beliefs about his classroom environment, as he says:

> "We get to blow things up. That's all they want to do in chemistry. Um, well, I had one student that said, you know, "Gosh, I've learned more in this class than I did in all my other classes," and it was one student that I didn't, um, particularly think was going to, ha, ha, succeed. I mean, she's doing well, but...I think if they can take out of my classes *some knowledge about themselves, especially in*

[5] For more explanation see teacher's view of content domain for Steve.

> *science, how is science important to their lives? Um, then that's an accomplishment...*" [emphasis added]

So, Steve believes it is important for his students to gain knowledge about themselves, not just a pure content knowledge which might be isolated from themselves and the real world out-side the school.

<u>Context</u>

The coded interview indicates that Steve's knowledge and beliefs about his classroom context are mostly early constructivist with some aspects of didactic.

As noted in the Teacher's Actions section above, he recognizes that time is the only impediment to his teaching in the way he would like. Also, he believes that state objectives influence his teaching (i.e., the level of flexibility of these objectives). He thinks that, "they [the state objectives] are more flexible than some people make them out to be." He definitely believes that these objectives influence his teaching. In the state where Steve taught, he used objectives which are based on the National Science Education Standards (NRC, 1996). The state objectives that influence his teaching were designed to integrate science content, the process of science and real world applications of science.

Steve suggests overcoming his constraints in away that suggests early constructivist teacher beliefs. He wants to offer extra time to meet with his students individually in order to determine their learning needs. As noted above, he says, "So I think it's just time. You can't talk to everyone, give everyone a one-on-one educational experience without more time." These teaching beliefs would suggest he is an early constructivist teacher in terms of knowledge and beliefs about his classroom context, because he uses the state objectives. He believes he needs more time to assess students' understanding in order to modify his plans and address students' misconceptions in his lessons.

Diversity

Steve believes that he can accommodate students with special needs in his classroom by changing the testing format and collaborating in this with the special education teacher in his school. These teaching beliefs would suggest he is a conceptual teacher in terms of knowledge and beliefs about his classroom diversity. He tries to do his best to accommodate their needs, as he says:

> "I do the best... on quizzes, tests, writing assignments, you know, either go ahead and ask them what they need, um. We have a great resource right here in the school that, you know, you give her a test problem and she reads the question for them and they feel real comfortable with it, so *I do my best to ask them whether they would prefer to take the test or an essay*" (TPPI, 1996). [emphasis added]

Philosophy of Teaching

The coded interview indicates that Steve's philosophy of teaching includes aspects of didactic, conceptual, early constructivist, and experienced constructivist teaching models.

Again, he believes that his students can learn science best if he provides them with answers, but in some cases he forces them to think about ideas instead of just giving them information. Giving students direct answers immediately without giving students time to think about answers to their questions would reflect a didactic teaching style in terms of his knowledge and beliefs about his philosophy of teaching. However, if he "forces them to think about it, " by using a conceptual understanding process, then as a conclusion, presents the current canonical scientific explanation (e.g., Roth, 1989), could reflect a constructivist teaching style.

Steve believes that his students can understand science concepts when they are able to, "ask questions above and beyond what has already been taught." He thinks that, "asking questions and designing something are valuable learning for them outside the classroom environment." These teaching beliefs suggest he is a conceptual teacher in terms of his knowledge and beliefs about philosophy of teaching, because he is encouraging students' questions that are both procedural and conceptual.

He also believes that students' engagement in subject matter and their abilities to make decisions are the primary goals of teaching. He says that learning is equal to knowing, they are, "about the same." Steve mentions his work with his mentor teacher in the last year (his internship) as the best learning situation that he has ever experienced. He learned many different things, as he says:

> "It was last year working with a mentor teacher. *I mean, not only was I learning things to teach the class, I was learning from him about school, and about subject matter, and about how to deal with kids and deal with parents and deal with administrators and, um, so, it's a one-on-one situation* and I think when you have a one-on-one situation, with someone and their expressed purpose is to help you, then that's about the best situation" (TPPI, 1996). [emphasis added]

This learning experience influenced his way of demonstrating an effective teaching/learning situation in his classroom. He wants to talk one-on-one with his students in order to know more about their educational needs. All of these teaching beliefs would place Steve's knowledge and beliefs about philosophy of teaching in the early constructivist domain, because he values strategies to engage students with subject matter.

Steve believes that he can learn science best by teaching. He describes how the activity of organizing science content so that he could teach it to his students caused him to deepen his understandings and grasp connections that he had previously not understood.

He thinks that writing skills are valuable learning for his students. He says:

> "If they can go beyond just the rote memorization of something and put a concept together with another concept or put ideas together, and usually that comes out in writing" (TPPI, 1996).

These teaching beliefs would place him in the experienced constructivist domain because he believes that writing can help students to develop conceptual understanding by putting concepts or ideas in science together (i.e., analysis and synthesis process skills).

Therefore, regarding philosophy of teaching, Steve provides evidence that represent a wide range of beliefs. This includes didactic teaching. However, this is not a major emphasis in his philosophy of teaching. His philosophy includes aspects of conceptual teaching (e.g., students are able to ask procedural and conceptual questions, and students are able to connect concepts together); early constructivist teaching (i.e., engaging students' in subject matter); and experienced constructivist teaching (i.e., using alternative forms of assessment to appraise students' learning, using teaching to construct learning).

Steve's Teaching Performance

Steve's video portfolio from his second year of teaching is of three consecutive days when he taught "Gas Properties" in his chemistry class for 11th and 12th grade students at Kroger High School. The total number of students in his classroom was about 20. Most of them were Caucasian. Students were sitting individually in desks arranged in rows. Some times they changed their seating while they were working in groups.

In the Salish Project, teachers chose which classes they wished to focus on. Generally, researchers understood that teachers chose their "best" classes. This was not the case for Steve. He chose his chemistry class because he wanted feedback on the class he found most difficult to teach. This perceived difficulty stemmed primarily from a feeling that his content knowledge was weaker in chemistry (his teaching minor) than in biology (his teaching major).

In the first lesson, Steve began by collecting the homework and answering the questions with the students. In the second half of the first lesson he asked the students to work in groups in order to figure out a gas's properties through relationships among Pressure (P), Volume (V), Temperature (T), and the number of moles (n). In the second lesson, he began by doing a chemical reaction as a demonstration to help students discover some gas properties. He then asked them to explain what happened and why. The last day was a review session to prepare his students for the quiz on the following day. At the end of each session students were asked to write a journal about the most important concepts that they learned in chemistry on that day. During the groups' work, Steve was moving from one group to another, answering students' questions and/or explaining procedural and conceptual issues to them.

These three consecutive videotaped lessons were analyzed by using the Secondary Teacher Analysis Matrix-Science Version (STAM). The analysis done using the STAM video portfolio for Steve's teaching performance is reported under several subtitles:

overview; teacher's content; teacher's actions; students' actions; resources; environment; and other, (for more information about the categorization of Steve's teaching performance see Table 9).

Overview

Steve's teaching performance is coded as transitional and conceptual, with some aspect of didactic and few aspects of early constructivist. Most of the time he did not reflect any deep understanding of the main concepts that related to the gas properties. Instead, he spent the three consecutive classes (180 minutes) teaching how to use one formula ($PV = nRT$), which he called it, "the magic formula." One key element in his teaching style is the degree of confidence with the subject matter, which he admits is low. This was reflected by the fact that he did not use any type of molecular representations to explain that gas pressure is a result of random collisions of moving particles of a gas with the walls of the container. These collisions exert a force per unit area that we perceive as gas pressure. This level of content knowledge in chemistry is considered basic knowledge to promote conceptual understanding.

Teacher's Content

The structure of Steve's content is descriptive and explanatory with some aspect of teacher and students negotiating understanding about teacher content.

He used only one equation ($PV = nRT$) during the three days of classes. One might say this is good practice. It is consistent with TIMSS[6] (1997) recommendations (i.

[6] This stands for Third International Mathematics and Science Study (1997).

Table 9: Video Portfolio Analysis of Teaching Performance for Steve

Area/ Teaching Styles	Didactic	Transitional	Conceptual	Early Constructivist	experienced Constructivist	Inquiry Constructivist
Teacher's Content	X	XX	X			
Teacher 's Actions	X	XX	XX	X		
Students' Actions	X	X	XX	X		
Resources	X	XX	X	X		
Environment	X	XX	X			

(i. e., less but deeper content is better). But in fact, in Steve's case he covered a lot of concepts without clear connections among them from the scientific point of view. For example, he covered gas pressure, volume, temperature, moles, collisions, fusion, osmosis, ideal gas, molecules, and chemical reaction, during the three lessons.

The subject offers many everyday examples that could be connected to the classroom work, but he stressed the mathematical (quantitative) aspect of the content (gas law). In a few cases, he pointed to examples of the relationships among these physical quantities. For example, he mentioned the reason for the cooling of an aerosol can after using it. His explanation was, "when you use that container the gas pressure inside it will decrease, so the temperature will decrease too." According to his explanations for this phenomenon, he did not make a clear connection among internal gas pressure, internal gas temperature, and external temperature (atmosphere temperature) that interact to cause the aerosol can to be cold. Also, he did not offer any explanation or ask his students for reasons that cause the gas pressure inside the container to be less when you use the container. So, Steve did not provide much evidence that he used any scientific models derived from the Kinetic-Molecular Theory of Gases to justify his explanation of this phenomenon.

He did not present the limitation of the laws; the content is very specific for "ideal" gases. He mentioned that all gases (i.e., ideal gases) under specific conditions ($P = 1$ atm, $T= 273$ °K, and $n=1$) have the same volume which equals 22.4L. However, there is no such thing as an ideal gas that obeys the equation perfectly under all circumstances; all real gases deviate slightly from the behavior predicted by the law (McMurry & Fay, 1995). For example, the actual molar volume of a real gas often differs slightly from the 22.414 L ideal volume (the actual volume of Argon is 22.09 L under the same circumstances, for example.)

This topic presented opportunities for explaining the process of, and history of ideas in science, but Steve did not integrate that in this class. Instead of explaining the process and history of science, Steve wrote out the formula on the blackboard and focused on the mathematical applications of that formula. Thus, he had the opportunity to explain how these quantities are put together in one equation. In addition he could have mentioned that this equation is derived from the Kinetic-Molecular Theory of Gases, which combines Boyle's law (P will decrease as T increases, at constant n and T); Charles' law (V will increase as T increases, at constant n and P); Avogadro's law (V will increase as n increases, at constant P and T); and Dalton's law ($P_{total} = P1 + P2 + \dots$).

At the end of each lesson, Steve asked his students to write a journal that reflected their understanding of the main chemical concepts that they learned through that lesson.

Teacher's Actions

Steve used 3 or more methods that were teacher-centered. He demonstrated one experiment, but it was not clearly related to the subject. The purpose of that experiment was to prove how gas can effuse (effusion is the escape of a gas through a pinhole without molecular collision). To produce a Carbon dioxide (CO_2) as a gas, he combined baking soda ($NaHCO_3$) with vinegar (CH_3COOH) according to this reaction:

$$NaHCO_3 + CH_3COOH \Rightarrow CH_3COONa + CO_2 + H_2O$$

He used candles as indicators to show Graham's law (the rate of effusion of a gas is inversely proportional to the square root of its molar mass). The demonstration was exciting to the students but it was not connected to the ideal gas law. For Steve, the main concern was to get the reaction done and form Carbon dioxide to put the candles out. The students observed that demonstration, but they were not able to make connections between the molar mass of a gas and rate of effusion from one side. Steve did not help students understand how this demonstration is connected to the ideal gas law (e.g., the relationship among the mass of a gas molecule, speed, pressure, and temperature) from other side.

Steve interacted with students by showing them how to use the formula. His questions were about the manipulation of the formula (e.g. uses of units). Questions were about the how to apply the formula, and end of the chapter problems from the textbook. Assessments were quizzes and homework. The uses of the assessments were for checking knowledge (procedural skill for the manipulation of one formula).

His responses to students' ideas about subject matter were often not reported through the use of the STAM, because Steve focused on the mathematical aspects of the formula. Teaching in this way allowed students to be able to execute the mathematics with or without understanding the underlying scientific concepts. Thus, most of the time the nature of dialog between Steve and his students was about the correctness of the mathematical procedure in order to get the right answer. In a few cases, he was seeking to change students' unscientific ideas (e.g., explain that the volume of the room is constant while the amount of gas inside the room is variable.)

Students' Actions

Students represented their ideas in writing as reconfiguration of information provided. Students engaged in procedural and conceptual questions, and they asked questions about how to solve problems, i.e., how to apply the equation. Student-student interactions about subject matter were rare; in a few cases, students interacted about the correctness of their answers. Students rarely initiated any activity; sometimes they offered some examples such as the application of carbon dioxide (e.g., fire extinguisher). Students clearly accepted the teacher's expectations about their learning content goals (i.e., solve mathematical problems), activities (students participated in classroom activities according to Steve's instructions), and assessment (i.e., test performance; students' questions were about the exam content). Students' understanding, in Steve's view, was demonstrated by solving mathematical problems based on the ideal gas law formula and by getting the right answers.

Resources

Steve used multiple resources (i.e., textbook, blackboard, periodic table, and laboratory materials) in his teaching. In general, the use of resources was related to the content. Students looked at, but did not actively use resources. As an example, Steve did the chemical reaction demonstration by himself without any help from students. Also, he answered all the questions on the blackboard, and while he was writing, he asked students about the right answer according to their homework. Usually he posted the right answer's numerical value and symbol for the questions that were assigned as a homework. He controlled the access to these resources. He rarely involved students in how and when to use these resources. For example, in the demonstration experiment, students were not involved in lab work using equipment and materials.

Environment

Steve made all of the decisions about class activities (i.e., it was teacher-dominated). However, the classroom had few attractive physical artifacts that related to science such as pictures, displays, etc. There were some teaching aids displayed. Most were not related to the content except the Periodic Table of the Elements. Students' work displayed was similar for all students (i.e., worksheets or journals)

Other

The videotapes did not provide significant information about group-interaction, or to student-student interactions. The deeper conceptual knowledge for Steve in this topic was low, the main indication for this impression comes from his teaching (he spent 180 minutes in doing applications to solve a one mathematical linear equation). The quality of student-teacher interactions was cooperative, but mostly the focus of interaction was about procedure and mathematical applications to the ideal gas law equation.

However, data provide only limited information about Steve's conceptual understanding or information on his lessons for teaching in this way. So, alternative explanation could be that he believes this way of teaching was the most appropriate way for his students to come to understand the relationships among pressure, volume, temperature, and number of moles.

One could infer this from the low-level cognitive goals in the three lessons. Steve did not emphasize a model of kinetic molecular motion, nor did he elicit or provide explanations using such a model. Instead, the focus of the interaction was about procedure and mathematical applications.

Student were always engaged and on-task, whether they were in small groups or working individually. Facilities were flexible and he changed format or activities frequently. Transitions were well organized and naturally smooth. His use of the time

Table 10: Summary of Analysis Results for Steve's Knowledge, Beliefs, and Performance

Area/ Knowledge, Beliefs, & Performance	Didactic	Transitional	Conceptual	Early Constructivist	Experienced Constructivist	Constructivist Inquiry
Teacher's Content	√	X √√	√	XX		
Self as a Teacher	X			XX		
Teacher's Actions	X √	X √√	√√	XX √		
Students' Actions	X √	√	XX √√	XX √	X	
Environment	X √	√√	√	XX		
Context	X			XX		
Diversity			X			
Philosophy of Teaching	X		XX	XX	XX	

√ represents teacher's performance and X represents teacher's knowledge and beliefs. XX or √√ means that the teacher's knowledge/beliefs or performance in this domain are more dominant than X or √. No mark in a category means that the teacher does not hold any aspect of knowledge/beliefs or perform any style of teaching in that domain.

was well organized. However, he did not present the content in deeper conceptual terms or include more real world applications (as he said he wanted to do).

Summary of Steve's Case

Steve Brook is a second year secondary science teacher who graduated from teacher preparation programs at North Global University. He taught tenth grade biology and eleventh and twelfth grade chemistry at Kroger high school in a small town. Most of his students were Caucasian.

Steve provides evidence that he had to some degree a consistency among his knowledge, beliefs, and performance. His knowledge and beliefs turn out to be conceptual and student-centered teaching styles with some aspects of teacher-centered. While, his teaching performance through the videotaped lessons was scattered between conceptual and teacher-centered with some aspects of student-centered. The summary of the analysis results for Steve's knowledge, beliefs, and performance is included in Table 10.

CHAPTER 4

Teacher Preparation Programs at South Global University and the Cases of Don & Kathy who Graduated from this Program

This chapter consists of three interrelated sections. The first section focuses on the teacher preparation programs at South Global University. This section is divided into two parts: Part (a) focuses on science content program which reported the analysis results of the science content courses that new secondary science teachers completed in the science disciplinary departments. Part (b) focuses on teacher education courses that new secondary science teachers experienced in the college of education, including science methods and general education courses.

The second section focuses on the knowledge, believes, and performance of Don, a graduate from teacher education program at South Global University.

Finally, the third section focuses on Kathy's knowledge, believes, and performance who graduated from two different Universities. She graduated from teacher education program at South Global University, but her degree in science was from different university.

Section One: South Global University Teacher Preparation Programs

In this section I describe features of teacher preparation programs at South Global University. Whenever teacher preparation programs are mentioned, it means both parts of this program: Science content program which took place within the science discipline departments; and teacher education program which is taught at the college of education, this includes general courses, for example, educational psychology, and foundations of education courses as well as courses in science methods.

The following sources were used to collect data: a) Data sheet for describing formal program operated by institution; b) Preservice Program Interview-Science Faculty Form; c) Preservice Program Interview-Teacher Education Faculty Form; d) Syllabus Analysis Form; and e) Preservice Program Interview-New Teacher Interview Form (NTI). Data were transcribed, coded, and analyzed.

In order to gain a clear vision about teacher education program features at South Global University I divide the analysis outcomes into two parts: 1) Science Content Program, and 2) Teacher Education Program. The reasons for separation that is the two components of teacher education program are different. After initial analysis to their data, it was evident that it would be appropriate to treat them as two separate programs as noted in Chapter 3.

Part a: Science Content Program at South Global University

Science content program features at South Global University were mainly extracted from Don's responses on the Preservice Program Interview-New Teacher Interview (NTI), Preservice Program Interview- Science Faculty Form (four faculty interviews were analyzed, one for a general chemistry course instructor, college physics instructor, astronomy instructor, and a general biology course instructor). Also, I used science content course syllabi. A summary of science content program features is included in Table 11.

Table 11: Science Content Program Features Matrix for South Global University

Feature/data Sources	Don	Kathy[1]	Science Faculty Interviews & Courses Syllabi	Summary
Objectives	All lecture-oriented, rote memorization.	Just understanding the principles.	Content knowledge, understanding. Practical application, & attitude toward science.	All lecture-oriented, rote memorization, understanding. Practical application, & attitude toward science.
Instructional Strategies	Lecture & lab	Mostly lectures	Lecture; recitation; lab, demonstrations, internet connections, computer lab, & hands-on.	Lecture; recitation; lab, demonstrations, Internet connections, computer lab, & hands-on.
Instructional Resources	Textbooks, lab manuals, & course notes.	Textbooks, lab books, take notes,	Textbook, courses notes, toys, lab manuals, Overhead visual materials, software, CD ROM, & computer homework assignments.	Textbook, courses notes, toys, lab manuals, Overhead visual materials, software, CD ROM, & computer homework assignments.
Methods of Assessment	Mostly short answer tests, lab write-ups, & lab journals.	Majority multiple choice tests, couple of essay questions, & lab hand-in.	Multiple choice tests, final, quizzes, homework, computer graded home work, essay exam, projects, & oral exam for make-up exams.	Multiple choice tests, final, quizzes, homework, computer graded home work, essay exam, projects, & oral exam for make-up exams.
Cooperative learning	Just in lab	One lab: a bio-chemistry lab.	Once a week in labs, homework, review sections, & small study group once a week.	Once a week in labs, homework, review sections, & small study group once a week.

[1]Kathy earned her B.Sc. in Biology/ Chemistry before he entered science education program at SGU. Her data from science program will be used only to know more about her scientific background.

Table 11 (cont'd)

Feature/data Sources	Don	Kathy	Science Faculty: Interviews & Science Courses Syllabi	Summary
Courses Audience	No, not at all for teacher.	No, for all science majors	Primarily pre-medical, non majors, and all majors.	Primarily pre-medical, non majors, and all majors.
Actual Research	Kind of solving some problems. A little in honors programs.	Never, never, not once.	Not in all courses, except in astronomy Students had three opportunities: Using the Telescope; visual observation; & using CCD camera.	Kind of solving some problems. A little in honors programs. Not common, Just in one class.
Important experience	College Physics: mathematical nature & demonstrations. Astronomy: a lot of demonstrations. Endocrinology lab: close to kind or research	Cell biology: linked a lot of the principles of biology & bio-chemistry, focused on all processes inside body cells.		College Physics: mathematical nature & demonstrations. Astronomy: a lot of demonstrations. Endocrinology lab: close to kind or research.
Student faculty relationship	Informal: not strong.	Informal: not strong.	Informal relationships with students.	Informal relationships between faculty and students.
Program Structure/ Cohort	No formal cohort in science classes	No cohort in science classes.	No, cohort in science classes	No cohort in science classes
Purpose of the Study	Going into medicine field.	Having a career of medical technology.		Medicine field.
Philosophy of Science			Science faculty either did not respond to or reported no philosophy of science	Science faculty either did not respond to or reported no philosophy of science.

1. Semester Hour Requirement

New Secondary science teachers are required to complete at least 56 semester hours of science including specific courses which provide certification in at least two subjects and usually three. In Don's case, who had a Biology major, and Chemistry/physics as a minor took 8 semester hours in mathematics. He took 8 semester hours in physics. Also, he took 29 semester hours in Biology, and 21 semester hours in Chemistry.

2. Course Objectives

Don as well as the science course's instructors mentioned that the main objectives of science courses were content oriented. Don says that, "it was pretty much , you know, cram as much stuff in your brains as possible, I think a lot of memorization and, ah, facts and formulas." In addition to those objectives, the Modern Astronomy course instructor added, "that simply to motivate them, that science is interesting."

Furthermore, a chemistry instructor reported that one of the objectives of the chemistry course was to focus on practical applications, as he says:

> "So the next course is a more practical application which I think that students who as they get through the beginning course, *find that course to be somewhat a little easier and then perhaps a little more interesting because it's application oriented* and we ask people to understand what the solvating processes are, for example, although the solvating process is no longer used, it still is a good example of chemistry and have them understand what steel is, what alloys are, understand what it means to have gold to a certain number of carats. It turns out to be something that women students in this class usually wake up and say - I wonder how many carats that gold is that I'm wearing on my finger. So the courses have different functions and they have different messages" (Preservice Program Interview-Science Faculty Form, 1996). [emphasis added]

3. Instructional Strategies

The most common instructional strategies in these science courses were lectures and labs, as Don says:

> "In the main content courses, not really that I can think of. I mean, it was pretty much, you know, you went to your , ah, you went to your lecture and some of the classes, you know, that if you were lucky you had some kind of a lab where you went for may be a three or four lab or something, you can go and, ah, you know, *there was a lot of learning in there I think than probably, um, at the lectures*" (NTI, 1996). [emphasis added]

In the astronomy class students were able to use the internet connections to update their information in astronomy discipline, as the instructor says:

> "And the visuals in the last couple of years, we've upgraded so that we have direct Internet connections so that the latest picture of Pluto, you know, released yesterday, is actually incorporated seamlessly into the lecture tomorrow and I think that gives not only dynamic pictures to look at but the sense that astronomy is an ongoing thing. That some of the lectures, I could not tell you all about it at the beginning of the semester because it had not been discovered yet" (Preservice Program Interview-Science Faculty Form, 1996).

4. Instructional Resources

Textbooks, courses' notes, toys, lab manuals, demonstrations, overhead visual materials, software, CD ROM, and computer home work assignments were used as resources for science instruction. Many of the science faculty members described the textbooks that they used by, "quite excellent in what we are looking for in a textbook." However, the astronomy class instructor reported that, some instructors used the textbooks without their test banks, because as one biology instructor mentioned, " I do not use their test banks. I think they are not very good."

5. Methods of Assessment

Science courses largely used objective tests (multiple choice exams and short essay). The using of these kind of tests as a tool to assess students understanding was justified by many faculty members in the college of natural science. Most of them referred to the big class size (the range between 350-1,100 students) in these introductory classes.

This justification was reported by the biology course instructor as well as others. She says:

> "*My problem with essay exams is when you read 400 essays, have you ever read 400 essays?* When you get to the end you don't know whether your standards have shifted or not. If I'd read this other one before I had coffee yesterday morning would it be the same, you see. And I worry about that. I personally, and then you add to that different people, then I feel the evaluation of those is so uneven that it may be less fair to the student then a multiple choice which is well crafted and I pride myself on being able to do that. I think some of the people who think it's not as good a test aren't very good at it. That's all that's going on there" (Preservice Program Interview-Science Faculty Form, 1996). [emphasis added]

Other evaluation methods were used in the science courses, but not common as the objective tests. Instructors used homework, computer graded homework, projects, and oral exam for make-up exams.

6. Cooperative Learning

In science classes cooperative learning techniques were often used in the laboratories and recitations (review sections). Mostly students work in the lab with a partner or small groups. Kathy reported that she used this technique in the advanced bio-chem. lab.

Also, Don reported that he did not use cooperative learning in most of his science classes except in the labs, as he says:

> "In most classes not at all. Except for like in the labs, you know, when we had classes that had labs. And really a lot of the science classes do have a lab that goes along with it but, um, in the labs there would be quite a bit of cooperative learning in a lab group or with a lab partner" (NTI, 1996).

7. Course Audience

Science courses were offered for all students and major students with only one reporting a non-major course. As Don said, "I think for everybody...I think at SGU they take all the same classes." For example, college physics course which Don took was for the pre-medical students.

8. Actual Research

All science instructors, except astronomy class instructor, reported that they did not offer opportunities for their students to do research. There were many reasons for not doing that. Some of them said the large number of students in each course. Another said, "we do have formal courses students can sign for independent study." While, some like the chemistry instructor thinks that would not be happened unless your are a students in the science program, as he says:

> "If students are in the bachelors of science programs, then they have an opportunity to do a research project. That would not be until their third or fourth year normally" (Preservice Program Interview-Science Faculty Form, 1996).

So based on that, prospective science teachers through this program are not able to experience actual research, because this opportunity is offer in the advance courses in science and usually most of education major students do not take any of these courses because they are not required in the program.

The modern astronomy class instructor believes that this is a suitable time for them to start acting as researchers. His class was reported by Don as an exciting experience for him. In this class the instructor offered his students three opportunities to do actual research. When he was asked about the experiences outside of the lecture class, "How often would you say students, whether it be through the labs or what not, have the chance to work on actual research projects or in research facilities as part of their experience in your course?" His response was:

> "Three opportunities. One opportunity for all of the students is actually extra credit. We have telescopes on the roof which you can look at with your own eyeball and check up on what I've been saying and if you write a one page report on it, you get extra credit points that are not insignificant kind of points. That, in fact, used to be required and we've shifted it to extra credit just as far as the attitude changed that this is a plus...Then within the labs we have two research projects. The first half of the semester, one which is based on a visual observations which is required of a wider variety of things and then the second half of the semester, we're actually beginning it this week, the first lab is doing it as we speak in fact, we're going to make use of a automated CCD camera we have on the roof to present it, with what they are getting right now, with a live demonstration. What's great is that with a CCD camera you can subtract out the daytime sky and you can see stars right now in the middle of broad daylight....Get some idea of how the whole system works in the first half of today's lab and in the second half of today's lab they're going to be presented with eight different options of types of research projects they could do as a class with it which they then discuss, work together, and come to a class consensus lab-by-lab. Each lab will make their own independent choice, what they want to do, then design the project, how long will be expose it, the camera and so on, and put together an observing file. Sometime over the next few weeks, pending on clear weather, that observation will be made automatically in the evening when they're not there and then towards the end of the semester they'll come back and look at the data that have come from the project that they designed and analyze that using the computers to get the rotation period of an asteroid or the motion of a comet or whatever one they have chosen. So everyone gets to participate in that project" (Preservice Program Interview-Science Faculty Form, 1996).

9. Important experience

Don mentioned that the college physics class was one of the two more favorite science classes to him, because he liked the content, "There was a lot of math involved in it and I like to figure out mathematical problems. Also, it had a lot of demonstrations." For the same reason he reported that he enjoyed the astronomy class. Don was helping the instructor and the graduate teaching assistant in the astronomy class by setting up the demonstrations, which the instructor had difficulty with. In addition to these two classes, Don had an endocrinology class that combined between lecture and lab. He was doing much better in the lab than the class because it, "was pretty interesting," as he says:

> "I enjoyed the lab a lot. We, um, dealt with rats every time and you would inject rats with certain, um, hormone and then, you know, cut them open later to see how it affected different things like the weights of tests or something like that. that was pretty interesting, I liked that. *It was kind of close to kind of research kind of stuff that was interesting*" (NTI, 1996). [emphasis added]

Kathy on her science program liked cell biology, it was advanced biology. She considered this class a the most interesting experience that she experienced in her science program, because "it really linked together a lot of the principles of biology along with the bio-chemistry and focused all on processes that take place inside body cells."

10. Student-Faculty Relationships

All faculty members and students agreed that the nature of student-faculty relationships seemed to be informal. Yet, Don questioned this relationship by saying, "they are cordial and they are nice... a lot of times you kind of wonder, you know, if they really care whether someone's learning or not." He explained his questioning by claiming that science faculty invest most of their time in research first, then teaching. In other words, they do not have time for their students.

11. Program Structure/ Cohort

Neither new secondary science teachers, nor faculty said that there was a cohort in science classes. In those science classes most of the students were all majors, with majority of audience from pre-medical students.

12. Purpose for Studying Science

Don started out as a science major because he liked math, but he was thinking also about going into the medicine field. He took biology as a major, and got minors in chemistry and physics. His major was intended to approach the medical field, "It would be better on my resume as having a science major so I switched over to biology." While, he took his minors in chemistry and physics because he knows that these two science disciplines need to have strong mathematics background in order to understand them, which he loves. The excited story started, when he got married and had kids, as he says:

> "By that time I started really looking at teaching. *Teaching was something that was in the back of my mind because I had enjoyed high school, I enjoyed teachers and learning myself and so I thought it would be something that I would like to share with other people....* When it came down to the end I applied to the graduate school for science education and I applied to medical school at the same time and, ah, got accepted to graduate school and eventually after a couple of rounds, I did not get into South Global Medical School and basically it was the only one I applied to and I decided if I did not get into South Global Medical School, and I decided I was not going to apply anywhere else....I am happy with that decision [being a teacher]" (NTI, 1996. [emphasis added]

Kathy also, had similar interests. She was, "mostly interested in a career of medical technology." She got a degree in biology as a good background that could fit with teaching or medical technology so she would be able to switch between those to fields.

13. Philosophy of Teaching Science

Science faculty either did not respond to or reported no philosophy of science teaching. But the hidden philosophy was to focus on science content they can deliver that to their students. Some of the science faculty believes in modeling connections between science and society as part of the course content.

Part b: Teacher Education Program at South Global University

Teacher education program features at South Global University were mainly extracted from Don and Kathy's responses on the Preservice Program Interview-New Teacher Interview (NTI), Preservice Program Interview- Teacher Education Faculty Form. The following faculty interviews were analyzed: Director of science education center, instructor of science teacher methods, instructor of foundations of education, and instructor of the applied chemistry), and some of the Teacher education Courses Syllabi. A summary of science education program features is included in Table 12.

Overview

Students, no more than 15 in a class, complete Methods I, II, III and then student teaching in sequence. They move through all four semesters as a cohort. Emphasis is on reading of relevant research literature, discussion, and modeling by the instructor. Practicum allow numerous opportunities to try out ideas, the majority of which are relating desired student goals with research about the role of the teacher and the effect of Teacher behavior on students. At the same time, teachers are considering how their classroom climate reflects their understanding of the nature of science.

Table 12: Teacher Education Program Features Matrix for South Global University

Feature/data Sources	Don & Kathy	Teacher Education Faculty	Teacher Ed Courses syllabi
Objectives	Experience (i.e., teaching). Nature of science. What education is all about, presenting research-based knowledge in science ed, and putting things in practice.	Having kids understand some content & some process objectives. Interactive learning Having a research base rationale for teaching. Having skills to implement that rationale. Apply what they learned in the methods courses. Asking questions Identifying basic chemical concepts in school curricula. Investigating various topics of applied chemistry.	Provide an overview of educational theories and philosophies which reflects the range of beliefs historically and established a foundation upon which students can build their own philosophies. Discussion & sharing experiences. Offer content relevant to students' needs. Model a variety of teaching methods and strategies.
Instructional Strategies	Small group discussion, actual teaching, video tapes of teaching, tape recording (i.e., students-teacher interaction, & reading assignments.	Discussion: Student talk 40%., teacher talk 60%, team work , lecture, asking questions, group lab investigations, & field trips.	Group project, observations, discussion, lab work, & teaching
Instructional Resources	Course packets, articles, current publication of science ed, books, pamphlets, hand-outs, textbooks, written notes.	Journal articles, films, videos, textbooks, SS & C assessment hand book, & lab activities.	Textbooks, articles, course packets, computer, videotapes, & lab manual.
Methods of Assessment	Written tests, Papers, presentations, performance (e. g., teaching duties and activities) in science ed, evaluation as a process of teaching, assignments,	Oral interviews, term papers, self evaluation, peer evaluation, University Evaluation form, videotaping, project s, presentations, Journals, exams (multiple choice & short answer in the applied chemistry class).	Participation, symposium & research paper, field trip, papers, portfolio, journals, work plans, participation, presentations, discussion, interviews, & resource notebooks.

Table 12 (cont'd)

Feature/data	*Don & Kathy*	**Teacher Education Faculty**	**Teacher Ed Courses syllabi**

Table 12 (cont'd)

Feature/data Sources	Don & Kathy	Teacher Education Faculty	Teacher Ed Courses syllabi
Cooperative learning	Mostly small groups in methods courses (e.g., lesson plans, Practicum work), very little in Ed courses.	All the science ed seminars, lab groups work, & small group discussion.	Small working group & groups project (e.g., field trip)
Research Experiences		None was reported by the instructors.	Field experience: Teaching, field trip, & group projects.
The Internship	Methods(I, II, III)	150 hours during three semesters prior to student teaching	
Field experiences	None in Ed courses. Actual teaching in the science Ed courses. It depends on the mentor teacher (i.e., hands-on). Teaching for few days.	Field experience in education was none. However, field experience in science education was at different grade levels and schools, was informative, and included full range of activities from observing to planning to teaching and assessing.	Observations, planning, teaching, and assessing.
Supervision	It was good. Helpful: suggestions & criticism. Instructors & graduate students.	Field instructors	Field instructors
Important Experience	Methods courses: teaching, reflection on videotapes, lots of ideas, students teaching.		
Student faculty relationships	Informal, more personal especially in methods courses.	Informal, close, & personal	
Professional Linkages	Both of them are members in NSTA. Don is a member of several professional groups.	Students were required to have membership at NSTA in methods courses.	
Program Structure/ cohort	Both of them went through the program in the same cohort.	Yes, but not broad enough.	

Table 12 (cont'd)

Feature/data Sources	Don & Kathy	Teacher Education Faculty	Teacher Ed Courses syllabi
Program Relationships	No, relationship. Methods courses learn how to teach the content which acquired from science courses. Ed courses give general ideas in education.	Informal, weak relationships with the science content departments.	
Prior Career	Kathy had 5 years as medical technologist & 8 years in health care data processing.		
Philosophy of TE program	Understanding of what science is, and how students learn it. Put research outcomes into practice.	Focus on *all* students (i.e., student-centered class). Using scientific knowledge instead of accumulating it. School students are able to make decisions about their learning. Teachers need to know how people achieve standards and expectations. Science, Technology, & Society (STS). Constructivism (i.e., constructivist teaching). Science is a social activity. Nature of science Science as a process (e.g., the ability of students to develop a good explanation). Total Quality Management (TQM): The value of having different approaches & customer satisfaction.	

Methods I: Meets for two and half hours a week plus four weeks in an elementary school. Working with the elementary students forces prospective secondary teachers to expand their repertoire of instructional strategies.

Methods II: Meets for seven and half hours a week. In this seminar instructor and students focus upon creating a rationale for teaching science. In this case a rationale is defined as a statement of purpose, strategy, goals, and evaluation for the science teacher. This rationale is developed during intensive seminar sessions. Students develop a set of goals for science education, read a variety of research papers, and analyze their goals in the light of what is known about the research on teaching, learning, and nature of science. They examine discrepancies between goals and behavior by identifying problems and cause-effect relationships. In this class, students have experience both in planning a lesson and in teaching a complete secondary science class. To make it somewhat easier on each student, students in teams of two or three prepare a lesson the will teach for three days in a high school physical science class.

They then go to the school and teach for three days, being videotaped during the lessons. After the teaching they return to the university where they critique their own tapes, critique the tapes of all other students, and have their tape critiqued by the instructor. Students spend about two weeks after this teaching revising their lessons and prepare for another try. Then they return to the high school and teach the same lesson to a different class. Again they are videotaped and critiqued.

The culminating moment in this second methods course occurs in a final examination. When the student sits down individually with the instructor for an hour and a half and defends a written rationale for teaching science at a particular level.

Methods III: Meets for four hours a week. This course emphasizes four aspect of teacher education: One-to-one communication skills, techniques and materials for personalized learning, adolescent cognitive psychology, and teacher self-evaluation. In the seminar, students develop discrete one-to-one communication skills and ways of achieving individual excellence. They examine materials, analyze teaching strategies, and practice skills during a teaching internship. To insure that this seminar entails more than just talking about education, a five-day-a-week, one-hour-per-day, clinical experience for 15 weeks is an integral part of this methods course.

1. Admission Requirements

Students can be admitted into this program by having minimum GPA of 2.5, at least 30 semester hours of science completed and senior status.

2. Types of Certification Awarded

The scope of this program is to certify teachers in grade K-6 Basic Science, General Science, Physical Science, Biology, Earth Science, Chemistry, And Physics. This program granted degrees in the following majors: Undergraduates can major in Science Education (a liberal arts degree), or complete a degree in any science department as well as the state specified certification requirements. Graduates may earn a Masters of Arts in Teaching degree while gaining certification. All programs require a minimum of two full years of study, regardless of entering degrees or coursework.

3. Semester Hour Requirements

The requirements of this program are that all students should complete at least 56 semester hours of science including specific courses which provide certification in at least two subjects and usually three. Coursework also includes two semesters of History and Philosophy of Science and two semesters of Applications of Science. General Professional Education coursework includes; Issues in Education, Educational Psychology, Human Relations for the Classroom Teacher, and Teaching the Exceptional Learner. Science Education courses include: Methods I (elementary, 37 hours seminar, 60 hours Practicum), Methods II (K-12, 112 hours seminar, 6 days Practicum), Methods III (middle school, 60 hours seminar, 75 hours Practicum), and student teaching (30 hours seminar, 16 weeks in both middle and high school with at least four teachers).

4. Program Purposes/Goals

The program goals are to develop analytical teachers who have a research-based rationale for teaching, skills and competencies as a teacher, and experience with a broad range of teachers, students, grade levels, and disciplines. Stress is placed on self-evaluation, use of research in developing teaching strategies, and considering the entire classroom climate.

5. Course Objectives

The objectives of general education courses were broad. Some of these objectives were addressed on the "Foundations of Education" course, which was taught to all education majors. This course was assigned for three semester credit hours. Course goals and objectives according to the Syllabus Analysis were to:

- provide an overview of educational theories and philosophies which reflects the range of beliefs historically and established a foundation upon which students can build their own philosophies.
- encourage student to think about selected issues in education and develop their own informed opinions about their impact on student as a teacher.
- give students an opportunity to ask questions and offer opinions on variety of educational topics.
- share their experiences including the instructor as teachers.
- discuss content relevant to student's needs as an educator, and

- model a variety of teaching methods and strategies.

In science education courses, especially in methods (I, II, & III), both instructors and new secondary science teachers agreed that the objectives of these courses were to have a research-based rationale for teaching, and the skills that need to implement that rationale. In other words, the objectives for these courses were to present research-based knowledge in science education and put things in practice (i.e., teaching). Kathy mentioned some of these objectives in her NTI (1996), as she says:

> "most of it was presenting, um, research-based knowledge of science education and then, um, putting that into practical "how to do" or "what to do" type of information, how it applied to a classroom."

For the applied chemistry instructor, one of the objectives was to change his students' ideas about the nature of a chemistry lab. So, he aimed to change the concept of chemistry lab from traditional lab that has been pretty much verification to a lab that helps students link things together in order to build a concept. As he says:

> "Chemistry lab has traditionally not allowed kids to try three more drops if two are recommended or try a little stronger or a little weaker solution that really stick, everybody since they're very nervously wringing their hands and my solution is to pick labs where you can alter solutions or alter the strengths or whatever or try with other things where there isn't really a hazard... instead of doing pre-lab write-ups, they do a journal which focuses on what they're doing right then and there, what happened, and why they think it happened to make this transition between what they do, what they see, and explaining it which is, again, even if you're doing a verification lab you still have to tie it back to what you know. Or if you're developing a concept, you want to tie it to what you think is happening so that you're building a concept" (Preservice Program Interview-Science Faculty Form, 1996).

6. Instructional Strategies

In general education courses, lecture was commonly used as an instructional strategy, although small group, discussion, and cooperative learning were used. Science education instructors used lots of discussion using readings and articles from journals, actual teaching, cooperative and small groups, videotaping, projects, labs, and hands-on activities.

7. Instructional Resources

In general education courses, textbooks, readings, and handouts were used by instructors. In science education, many instructional resources were used such as readings, lab manuals, lab activities, textbooks, audio-visual, computer software, course packs, SS & C assessment handbook, and written notes.

8. Methods of Assessment

A wider variety of assessment were used by science education faculty than general education faculty. Science education faculty used authentic assessment such as personal interview, portfolios, journals, projects, self evaluation, peer evaluation, presentations, field trip, resource notebooks, and work plans. Actual teaching/performance was also used. In the applied chemistry course, in addition to a project paper, the instructor used multiple choice and short answer tests.

Don reported that in methods courses, students were involved in the evaluation process. He valued this strategy because it helps him make a reflection on his performance. For him being immersed in the evaluation it is a, "teaching tool," as he says:

> "It is good.... *it forces you to reflect* I guess, you know, and *reflection is kind of an important part in teaching and I think that is probably something they were looking at when they did that kind of thing* because you have to do it in and you have to reflect back on what you have done and see if you have really met the objectives you were supposed to and really are kind of forced to be real honest with your self on what you have done and what you have met. *In that way I think that is probably, you know, a good teaching tool*, you know, it is an evaluation process but it is kind of a teaching tool in the same way" (NTI, 1996). [emphasis added]

9. Cooperative Learning

Science education faculty and students agreed that cooperative learning and small group work were more common instructional strategies in science education courses than general education courses, especially in science education seminars. As Kathy says:

> "Oftentimes we were assigned to do lesson plans that could be done with other students. Um, some Practicum work- I remember in Methods III we went to (City name) and taught for a few days and doing some group work with other science education students" (NTI, 1996).

The director of science education center confirmed that all the science education seminars have some sort of cooperative learning. He says:

> "*Maybe it is not exactly cooperative learning* but it certainly is not like- here are the rules and you take them out and make sure they are going on in the school. But what is going on in the school is then brought in and sort of analyzed and discussed" (Preservice Program Interview-Teacher Education Faculty Form, 1996). [emphasis added]

10. Research Experience

Neither new secondary teachers nor faculty at science education program mentioned that the used actual research in science education classes.

11. The Internship

The internship in science education program was 150 hours during three semesters prior to student teaching, all with supervision and seminars. Student teaching was a full-time, 16 week program with at least 13 visits by Science Education Center staff during the semester.

Prospective secondary science teachers were required to have teaching experiences in different grade levels: elementary, ninth, and middle school/ junior high. The elementary experiences were most frequently in kindergarten. The rationale of asking those teachers to have teaching experience in the kindergarten level was to put them in a situation that required them to think about the most appropriate instructional strategies that fit with this level of students. For sure, lecturing in kindergarten will not work. This rationale was explained by one of the methods courses instructor, who says:

> "The real reason, however, is that if I took most of our students, who are pretty well educated in the sciences, put them in a high school class here, they could contentedly lecture about whatever they wanted and the good students in the district would take notes placidly and not complain, by and large. If I put them in a kindergarten class, nobody says, well, I want to go out and lecture. Instead they say, "My God, what am I going to do?" And we say, "Well, what are your goals for these students?" They say, "Well, gee, kindergarten, it's not going to be astrophysics, they ought to think it's fun, interesting, exciting and they should say, I can do science." "What do you know about how kindergarten learn?" "Well, it's not by lecture, it's not by movies. They can't follow directions, they can't read. Guess I'll do a lab activity. But the lab can't be anything very serious because they can't follow directions. So I guess we'll do a lot of messing about. Give them test tubes and they'll pour things and they'll think it's fun and neat." "And how does that match up with what you know about how kids learn and how teachers teach?" And they discover that it's compatible" (Preservice Program Interview-Teacher Education Faculty Form, 1996).

12. Field Experiences

Neither Kathy nor Don had field experience in any general education courses. However, their field experience in science education was at different grade levels and schools, was informative, and included full range of activities from observing to planning to teaching and assessing.

Don reported that his field experience in science education, "was actual field experiences... that is why I got hired at my job because they felt I had lots of experiences and I had not even been a teacher yet."

Kathy's field experiences ranged from, "it was a real difficult semester," to "it was a good experience." Kathy in her field experience observed a few hands-on activities and she taught in middle school.

13. Supervision

Prospective secondary science teachers were supervised by science education faculty and mentor teachers. For example, in student teaching there were at least 13 visits by Science Education Center staff during the semester. Some aspect of the supervision nature was explained by the methods instructor, as he says:

> "I get 50 hours from looking at the final interviews plus the time out in schools. About 36 hours out in schools and about 14 hours in the interviews when the class is small. When the class is full size you can add another 15 hours to that. In fact, the final interview alone adds 1 1/2 hours a week, on average, to the instructional load and I think it's fully worth it" (Preservice Program Interview-Teacher Education Faculty Form, 1996).

The goal of supervision in science education program was to support new secondary science teachers with a feedback about their students teaching. As Kathy mentioned, "well, these are your good behaviors, these are behaviors you need to work on, instead of doing this maybe you should try this."

14. Important Experiences

Don and Kathy recognized their science education seminars as important experiences. They believe that these courses were designed to teach them how to teach the material they intended to teach. For Kathy it was student teaching. However, her experience in methods III was not real growth for her because she was not assigned to a good model teacher.

Don reported that, "methods were by far the most valuable of any of them." These courses gave him the chance to experience teaching in the real world (a school setting). Also, he appreciated videotaping his own teaching because this would allow him to make reflection on his teaching, for him it was a, "big learning style."

15. Student-Faculty Relationships

New secondary science teachers and their faculty agreed that they have informal relationships (i.e., personal & close). Don had a very close relationships with most of his science education instructors, even "it was better I guess than maybe the science content relationship." Also, Kathy had personal relationships with her instructors in the general education courses and science education courses, "I think both of them, um, I felt that, um, the instructors knew me fairly well."

16. Professional Linkages

In science education program professional linkages are required in the methods courses. New secondary science teachers were asked to have a membership in NSTA. Kathy and Don have a membership in NSTA. In addition to that, Don is a member of several professional groups including: State-SEA, State-STA, NEA, and the local education association.

17. Program Structure/ Teacher education Cohort

Cohorts do formally exist in science education program. New secondary science teachers recognized that were a cohort in their methods courses, as Don said, "we got to work in small groups within our 15 and, you know, and I worked with all of them fairly close."

But from the faculty point of view, this cohort was not so strong, especially with the professional courses, as the applied chemistry instructor says:

> "I suppose there is some... .probably the most trouble I see with our program with a lack of coherence is with the professional courses the kids have to take, the four outside of the college... there is about 12 hours of coursework that really could be making an impact if it were more clearly focused" (Preservice Program Interview-Teacher Education Faculty Form, 1996).

From an administrative point of view, the science education director rated the program coherence (science content, college of education, and science education) as, "I would probably give it an overall of C+."

18. Program Relationships

Both faculty groups from TE department and College of Natural Science admitted that the nature of the relationships between the faculty members in those two programs (science education program and science content program) were informal and not so strong. As the director of science education program mentioned that this relationship, "It could be stronger."

On the other side, the applied chemistry instructor still see this relationship as informal and it is varies from year to year. Yet, even if it is informal, he thinks that this relationship with physics department, "right now is pretty good," the same with the biology. He thinks chemistry is, "the hardest one."

19. Prior Career Influences

Kathy had a prior career before being a teacher. She worked five years as a medical technologist. Then she worked eight years in health care data processing doing a lot of customer interactions and some very simple programming through customized software for health care users. After that she returned to school and entered the science education program at South Global University. Her prior career experience helped her to deal with students and take care of them. She was able to benefit from this experience by making connections between her background in (health care, human health, and diseases) and teaching biology. She described this experience as helpful, as she says:

> "... those years of experience indicated to me the importance of training employees and in the, you know, education within the work place and also what types of behaviors and skills make you a good employee. During the medical technology years, I just got a lot of good background on the human anatomy of physiology, you know, put into use. Um, I do not know, I learned a lot about health care, and human health, and diseases the background in that... a lot of times, when you teach biology, kids really like to hear about actual case studies. They love that" (NTI, 1996).

20. Philosophy of Teaching

The philosophy of general education courses were to focus on different learning styles and customer satisfaction (i.e., Total Quality Management). Both, science education faculty and prospective secondary science teachers agreed that students should understand science (i.e., nature of science) and how students understand it.

The science education faculty reported largely that their philosophy was constructivist and promoting reflective teaching. This philosophy was expressed implicitly by the science education directors, as he says:

> "I sometimes argue that the rationale for those application courses is that it is an experience with STS, organized around problems and questions and if you are teaching from the students' perspective, if it is student-centered and that they're using their prior knowledge and experience and whatever else, not only to identify questions but to point out where they're going to find answers, what resources they're going to use and what they're going to do about it, seems to me that those aspects of teaching that use student constructions already there and hopefully are designed in a way to change their constructions, their interpretation of meaning, that those are the two things. Taking advantage about what we know about learning, which you have to change your teaching of that if you want to use the word constructivist teaching. Although, the constructivists never really talk about teaching" (Preservice Program Interview-Teacher Education Faculty Form, 1996).

Section two: Don's Case Study

Don Miller (a pseudonym) is a second year secondary science teacher in his mid-twenties. In 1994, he graduated from South Global University with a biology major and chemistry/ physics as a minor. He is certified to teach in all science disciplines. He had more than 100 hours of field experience before he began student teaching. His student teaching assignment was 2 Life science, 2 Earth science, and 2 General science for the middle school level (6-8). Also, he taught one Physical science courses to high school level students (9-12).

Background

During his preservice teacher education course work, Don took introductory courses in biology and chemistry, and the associated labs. In addition to that, he took courses in organic chemistry (I & II), and organic chemistry lab. In biology, he took fundamental genetics, biochemical molecular biology, fundamental genetics lab, cell physiology, evolution, and honors lab research in biology.

Don's background in physics and mathematics was 8 semester hours in mathematics (calculus I & II), and 8 semester hours in physics (college physics I & II).

His pedagogical training in teacher education was through the MAT program at South Global University. He took science methods courses (I, II, and III). In addition to that, he took courses in applied physical sciences, applied biology sciences, science history perspectives, meaning of science, elementary special subject student teaching, general laboratory, general astronomy, and lab Practicum for secondary science teachers (I & II).

Don's pedagogical background in education was from College of Education courses that he took through his teacher education program. Don took courses in child development, educational psychology, human relations, and issues in education.

Teaching context

Don began teaching at Olan Mills High School (also a pseudonym) in 1994 after graduating from the teacher education program. He taught 9th grade physical science at a small school in a rural, mid-western community of 2,500 people. Approximately, 95% of all local community residents in Olan Mills High School earned incomes of less than $40,000/year. The entire Olan Mills High School system consists of about 1500 students in grade K-12.

Don's teaching load consisted of six periods of 9th grade physical science each day. As is the case with most new teachers, he was assigned to several non-teaching duties including: coaching, faculty committee work, class advisorship, club sponsorship, study hall duty, lunchroom duty, hall duty, detention monitor on a rotating basis, and homeroom supervising.

Most of his students are Caucasian. He had 60 male students and 68 female students. Don had about 20-30 students in his classes who were classified as having special needs. He usually addressed their needs by using sign-up schedules for before and after school and during planning periods for tutoring sessions. He used mandatory once a week meeting for students with grades of D & F, and points were given for students' desire to improve. Sometimes, he sent his students with special needs to the Resource Center.

Don had no computer in his classroom, but he had access to the computer lab once a month. Usually, he used this lab for writing inputs and papers. In addition, he had access to the laser disc players, CD-ROMs, and a modem.

Don used Physical Science, first edition, (1993) as a textbook in his class. This textbook comes with tests, worksheets, quizzes, activities, reviews, and other supplementary resources. He usually spent 15-20 hours per week preparing to teach science.

In his questionnaire (SIDESTEP, 1996), Don lists the following methods of assessment to assess his students' understanding in science including: group work, worksheets, discussion with students, essay/short answer, projects, oral reports, homework, lab write-ups, and performance exams (students were asked to do demonstrations in front of him).

Don is a member of several professional groups, including: NSTA, NEA, the state science teachers' association, and the state and local teachers' union. In the past year, he attended one national science teacher conference, but he did not present there. Moreover, Don assisted his wife with advising pep club and cheerleading.

Don's Knowledge and Beliefs

Don's knowledge and beliefs are documented by using Teachers' Pedagogical Philosophy Interview (TPPI, second and third year teacher, 1996). His interview was audiotaped, transcribed, coded, and analyzed. HyperRESEARCH software was used on the process of coding and analysis. Most of his knowledge and beliefs can be described as early constructivist teaching style in most of the TPPI categories, except in teacher's knowledge and beliefs about view of science content. In this category, he holds a conceptual teaching style as dominant. Also, Don holds some aspects of didactic, transitional, conceptual, and experienced constructivist knowledge and beliefs about teaching. The summary of the analysis results is included in Table 13.

Don's Views of Content

The coded interview indicates that Don's views of teaching science content are mostly conceptual with some aspects of transitional.

He is a physical science teacher for 9th grade. He believes that the most important science concepts for his students to understand by the end of the school year are sound, light, fluids, forces, and Newton's Laws. In the first semester he taught general chemistry concepts, his student did a big project and they built a gigantic periodic table. In his class he tried to cover the most important basic general background in science because he wants to give his students the opportunity, "to choose what area they like the most."

Table 13: Analysis of Don's Knowledge and Beliefs

Area/Knowledge & Beliefs	Didactic	Transitional	Conceptual	Early Constructivist	experienced Constructivist	Constructivist Inquiry
Teacher's Views of Content		X	XX*			
Self as a Teacher		X		XX		
Teacher's Actions				XX	X	
Students' Actions		X		XX	X	
Environment				X		
Context				X		
Diversity		X	X			
Philosophy of Teaching	X	X		XX	X	

* XX means that the teacher's knowledge and beliefs in this domain are more dominant than X. For example, Don's views of science content knowledge and beliefs are mostly conceptual (XX) with some transitional aspects (X). No mark in a category means that Don does not hold any aspect of knowledge and beliefs about his view to the science content knowledge in that category.

In his questionnaire (SIDESTEP, 1996), Don listed the top three goals in order of importance that he holds for his students:

> "To realize how science influence nearly every aspect of their lives and that it is an ever changing field with "truth" being the best explanation at the time.
>
> "To be able to begin to think logically and work problems out step by step. I also would like my students to be able express themselves or explain their thoughts better on paper.
>
> "To have a working knowledge of concepts not to just recall but to apply."

He wants his students to think that science applies to their life,

> "But it is important for me. *I want them to be able at the end of the year to say, ok, this concept explained why this happened, this explained why this happened. um, and I see how science applies to my life*" (TPPI Interview, 1996). [emphasis added]

According to the TPPI supercodes this suggests that he holds some aspects of transitional teaching beliefs, because he mentioned that, "science applies to my life." However, he believes that his students are able to make sense to the world around them by using the scientific knowledge. As a result of using this knowledge, students are able to make that connection between main ideas in science and the real world. Don wants his students to understand what the main concepts of science are and to be able to use this knowledge to explain things. Moreover, he wants them, "to have a working knowledge of concepts not to just recall but to apply."

Self as a teacher

TPPI supercodes indicate that Don's self as a teacher is both transitional and early constructivist, but his early constructivist knowledge and beliefs about himself as a teacher were dominant.

Don would like to organize his classroom to let the students move around, because he wants to change his classroom physical environment to facilitate learning.

Don describes a well-organized classroom as:

> "I like it so that students feel they can move around, you know, when I guess they are supposed to be but, um, if you walk in it will be kind of, ah, it will not be the quietest room. *It is kind of loud but hopefully not to the point where it is being distracting from the learning and being able to talk and share their ideas*" (TPPI Interview, 1996). [emphasis added]

Don believes that his main strength is his ability to relate to his students. For example, he cares about his students, has good relationships with his students, and has a sense of humor. In the TPPI transcript (1996) when he was asked about his main strengths as a science teacher, he said:

> "*I care about whether they learn* and I do not want any student to ever say that I do not whether they got an A or whatever. I mean, I want them to know foremost that *I definitely care about what they do, you know, if they succeed or fail*, I care about that and *I guess having sense of humor is my other one.* And so *I usually have a pretty good rapport with the students where I can*, you know keep them interested through humor." [emphasis added]

It is clear from this quote that Don cares a lot about his students' learning and he is willing to build strong relationships with them.

<u>Teacher's Actions</u>

The coded interview shows that Don's actions are mostly early constructivist with some aspect of experienced constructivist.

He believes that time is one of the constraints. The big problem in his situation was to monitor students while they were working in their "Roller Coaster" projects. He wants to give more time for his students to work independently.

Also, he thinks that one of the biggest problems:

> "*...is having parents understanding exactly what my objectives are when I am teaching*. I think a lot of that might be my fault... .When I talk about the roller coaster project, I wrote objectives and everything out for students that I did not require them to take them home and next year that is on the agenda where they take them home and have them signed" (TPPI Interview, 1996). [emphasis added]

So, Don is willing to get parents involved in the process of teaching, learning, and assessment.

Don decides to move from one concept to another, when 90% of his students understand the concepts that were covered. He used projects in his teaching as an assessment tool. This reflects him being experienced constructivist, because he uses students' understanding as criteria in his teaching (i.e., he makes his teaching decisions based on students' understanding). Moreover, he uses group wok (i.e., projects) as a technique to assess students' understanding.

Students' Actions

TPPI supercodes indicate that Don's Students' actions in the classroom are transitional, early constructivist, and experienced constructivist.

Don believes that you have to change the classroom setting to accommodate students with special needs. For example, he sits students with hearing problem somewhere closer to the front.

Don believes that most of his students can learn science best by the same way he learned science, he says:

> "*I assume most of the students learn [science] the same way...* trying, getting the problem, trying to attack the problem, and see what happens and what worked and what did not work and knowing how to use that the next time we do it" (TPPI, 1996). [emphasis added]

So, he thinks that all students can learn science in the same way (i.e., there is no diversity in students' learning).

However, Don is willing to use different strategies to help students understand the activities. Thus, he changes students' perceptions about the necessities of knowing. He wants his students to experience different instructional strategies and different methods of assessment to assess their understanding of the scientific concepts, more than traditional ways of assessing students' understanding (i.e., tests and quizzes). Yet, the nature of those tests is factual recall, "memorization of a text." These teaching beliefs were included in the his story when he describes his best teaching experience, as he says:

> "This girl that I have in my class this year, *she is really a neat person* and, um, at the beginning of the year when we did... these roller coaster projects and that was just a huge, um, production... *but it was this gigantic project and it was all surrounding was velocity, acceleration, and measuring time and distance and they had to build this big roller coaster*....She started in on the project and *at first it was kind of exciting and then after a while, um, people kind of got scared thinking it was going to be an impossible project* and then I think we kind of came full circle and by the end we were excited about it again. *But she, this project just killed her and we talked about it with the principal and talked about with her parents and everything and this is a straight A student.* She never got anything other than A and ah, she came to the point where she actually and asked me, *"can you just give me some notes and give me a test on anything."* She asked me, you know, it was unbelievable to me why anybody one would want to just take notes and take a test. *But I was trying to convince her that there were other styles of learning that she needed to show me that she could handle and this was one that shows her creativity and, ah, her skills of tackling a problem and meeting the requirements*....So anyway, I think we got past that and *she ended up coming up with a pretty good results, it was not the greatest but it was alright.* So we moved on. Then we came to another project. *It was basically the same kind of thing but this time it had even less requirements and I said how I want a project on electromagnetic spectrum and you do anything you can to present that information as creatively as you can....She jumped right into it and she ended up being a 25 minute video on the electromagnetic spectrum and it was just incredible*" (TPPI Interview, 1996). [emphasis added]

Moreover, he believes that teacher needs to make some changes in the assessment process to fulfill students' needs. Don has a student who can not read at all, he would not even be able to tell what the test said! He overcomes this problem by sending this student sometimes to the resource center, or he asks him the test questions verbally. So, Don made changes in his teaching strategies, assessment methods, and expectations to fit with this student's needs. These teaching beliefs were mentioned in his story when he describes his strategies to deal with students who have special needs, he says:

> "*But if I said, okay, give me an example of how, Newton's First Law in like when you are driving down the road or something? And he can give me, if that was his question on the test, if he had read it he would not be able to give me an intelligent answer but if I ask the question he can give you 1,000 answers.* He is very bright when the thing is read to him, but, you know, if he reads to himself, there is not a chance" (TPPI Interview, 1996). [emphasis added]

<u>Environment</u>

Don wants to see his class as the most attractive class for his students, he says:

> "If they are going to be in school, then, you know, they want to be in your class. Um, that is kind of what *I want them to see the kids acting like rather then just dreading that if they have go to the class it is going to be terrible* and they do not have to learn anything that way I do not think" (TPPI Interview, 1996). [emphasis added]

Also, he thinks that his students will like the class because of social aspects (i.e., science was fun and applicable). These beliefs would place him in the early constructivist category in terms of his knowledge and beliefs about the classroom environment, because he wants his classroom to be a student-centered.

Context

When Don was asked about, "what are some of the tactics you use to overcome these constraints,"[2] he did not identify much that he has done, but there were indications about what he would like to do in future years, such as better communication of objectives with parents. His attention to his students with the severe reading difficulties was a way of dealing with a constraint.

These teaching beliefs suggest that Don's context in terms of his knowledge and beliefs is an early constructivist, because he admits that there are some constraints that he needs to work on. For example, make better communication with parents to involve them in students' learning, and pay more attention to students with special to help all students develop understanding.

Diversity

Again, Don recognizes that teacher should accommodate students with special needs by changing classroom management (e.g., hearing impaired sit near front of the room).

He also reports meeting special needs by changing expectations such as employing different assessment methods.

Philosophy of Teaching

The coded interview indicates that Don's philosophy of teaching are scattered among didactic, transitional, early constructivist, and experienced constructivist.

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[2] These constraints were explained in Teacher's actions domain.

Don describes a good learner as someone with basic skills (i.e., listens well). He learns best by doing things, trying things out, and seeing what happens. He believes that his students can learn in the same way.

Don thinks that the founding principles of teaching are having students be interested in what they are learning, and having experiences to try to apply that information or to present that information in creative ways.

Therefore, regarding philosophy of teaching, Don provides some evidence of beliefs that represent didactic, transitional, and experienced constructivist teaching styles but the major emphasis on the beliefs about philosophy of teaching is on early constructivist.

Don's and His Students' Beliefs about the Learning Environment inside the Classroom

These beliefs about the learning environment for Don and his students were measured by using CLES through the Salish Project. Students' scores were measured for five different classes. The number of students who responded to the survey was 45. Mean scores were calculated. Don and his students' results on CLES are summarized in Table 14.

Don perceives that what he teaches in his science class is more relevant to the lives of students out-of-school, than his students according to the Personal Relevance Scale (PR). Don's score on this sub scale was 28 and his students was 24.4

Table 14: Don's and His Students' Scores on the Constructivist Learning Environment Survey (CLES).

CLES Sub Scales	Don's Score	Don's Students Mean Score from Five Classes (n=45)	National Sample: Science Teachers Mean Score[3] n= 69	National Sample: Students Mean Score n> 5,000
Personal Relevance (PR)	28	24.4	24.8	23.3
Scientific Uncertainty (SU)	26	22.7	22.6	22.6
Critical Voice (CV)	32	24.6	Not available	24.3
Shared Control (SC)	17	15.2	20.8	17.2
Student Negotiation (SN)	30	21.6	Not available	22.6

Also, Don sees science as more uncertain than his students do. He sees science as an evolving activity embedded in a cultural context and embodying human values and interests, while his students perceive that less. He scored on Scientific Uncertainty Scale (SU) 26, while his students scored 22.7.

He strongly believes that his students are able to legitimately exercise a critical voice about the quality of their learning activities, while his students perceive that much lower. He scored on Critical Voice Scale (CV) 32, but his students scored 24.6. This means that, in comparison to this teacher (Don), students believe they have little input about the nature of their learning environment.

Don and his students have a small difference on their perceptions over the control of classroom learning environment but both scores are low. He and his students believe

[3] Not all data for CLES scales were available for new secondary science teachers.

that the students are involved in the management of classroom learning. He scored 17 on Shared Control Scale (SC) and his students scored 15.2.

Don scored himself notably higher than his students in Student Negotiation Scale. He thinks that his students have input about their learning inside the classroom (i.e., students have a positive role inside the classroom). For example, he believes that student-student interactions for the purpose of building their scientific knowledge within the consensual domain of the classroom is important for students' learning. His students mean score on the Student Negotiation Scale (SN) was 21.6, while he scored 30.

Don's Teaching Performance

Overview

Don is an early constructivist with some aspect of conceptual and experienced constructivist (see Table 15). He taught the Electromagnetic Spectrum and its applications in every day life through four consecutive days.

During three of the four sessions, he did many demonstrations to help his students understand these ideas. On the second session he and his students constructed a table that includes criteria to grade students' assignments. Don is an optimistic teacher, he tried hard to help students understand the main concepts in one of the most abstract topics in science, the "Electromagnetic Spectrum".

Teacher's Content

The structure of the content for Don is mainly explanatory with students and teacher negotiating some understanding. He used many demonstrations to explain the components of

Table 15: Video Portfolio Analysis of Teaching Performance for Don

Area/ Teaching Style	Didactic	Transitional	Conceptual	Early Constructivist	experienced Constructivist	Inquiry Constructivist
Teacher's Content	X		XX	XX	X	
Teacher's Actions			XX	XX	X	
Students' Actions	X			XX	XX	
Resources			X	XX	XX	
Environment			XX	X	X	

Electromagnetic Spectrum. He explained the differences among these components according to the wavelength and frequency. Examples and connections led by Don.

Don did not present the limitations, exceptions, or multiple interpretation to this topic. Moreover he did not pay any attention to the laser safety in his class. As an example, he shot laser beam onto the forehead of one student while showing his students some applications of laser light. Nothing was mentioned about the history of science. The processes of science were integrated by the teacher (for example the students and the teacher used the laser beam to derive the laws of reflection and refraction).

Teacher Actions

He used many teacher-centered methods with some student-centered methods. He used many demonstrations that were conceptually focused (for example, UV, laser, microwave, x-rays, and etc.). Teacher-student interaction was focused on the clarification and usefulness of students' ideas. Both teacher and students had input (i.e. Constructing the scoring rubric table). Don's questions focused on concepts and connections with some questions emerging from students' ideas and instructional objectives.

Don used multiple forms of assessment (for example, he asked his students to design a poster, pamphlet, page of a book, or a transparency that reflected their scientific understanding to a magnetic spectrum topic). He and his students used the assessment in addition to grading to adjust activities. His responses to students' ideas about subject matter were seeking to change the students' unscientific ideas. Table 16 shows an example of a scoring rubric he created with his students to evaluate their work on a poster project.

Table 16: Grading Rubric Table Constructed by Don & His Students

Criteria/ Grade	1	2	3	4	5
Information & content	Visible/ invisible		Examples		Diagrams, extra information
Uniqueness	No color No diagram		little colors		poster very colorful
Creativity	Photocopy of original		Pictures, some words		"Wow factor", eye catching
Effort	minimum		average		complete, well done, comparison to the class

Students Actions

Frequently, students used writing and other representations of ideas to construct their understanding of the main concepts. This was clear when the teacher helped the students to set criteria to judge their assignments (see Table 16). Most of the students' questions were conceptual in nature, while some were procedural in nature. Student-student interactions about subject matter were not observed on these four consecutive lessons. Most of the time students contributed examples and analysis, most of these examples were pertinent. Students' understanding of teacher's expectations included some frustrations with role, and sometimes roles and procedures were negotiated with students.

Resources

Don used multiple resources (for example, visual aids, videos, manipulative, laboratory materials, technology). Uses of resources were to aid many understanding and applications. He controlled the access to these resources.

Environment

Many decisions in this class were joint decisions made by Don and his students. Many teaching aids displayed were related to content. There was no direct evidence for students' work displayed, but from the statements he shared with the class there will be more displayed in the future.

Other

The accuracy of content for Don was high through the video taped lessons. The student-teacher interactions were cooperative. Most of the time students appeared to be engaged and on-task. Transitions were well organized and naturally smooth. Use of the time was well organized. Facilities were flexible and changed frequently.

Don did so many demonstrations that he left little time for each activity. He spent much time in constructing the Rubric Table, but if it is to be used for the whole semester this will be fine. Four students participated in the demonstrations; three of them were male. Male students asked more questions than female students. Female students seemed more excited by the demonstrations.

Summary of Don's Case

Don Miller is a second year secondary science teacher in his mid-twenties. In 1994, he graduated from South Global University with a Biology major and chemistry/physics minor. He is certified to teach all science disciplines.

He began teaching at Olan Mills High School in 1994 after graduating from the teacher education program. He taught 9th grade physical science at a small school in a.

Table 17: Summary of Analysis Results for Don's Knowledge, Beliefs, and Performance

Area/ Knowledge, Beliefs, & Performance	Didactic	Transitional	Conceptual	Early Constructivist	Experienced Constructivist	Constructivist Inquiry
Teacher's Content	√	X	XX √√	√√	√	
Self as a Teacher		X		XX		
Teacher's Actions			√√	XX √√	X √	
Students' Actions	√	X		XX √√	X √√	
Environment			√	X √√	√√	
Context				X		
Diversity		X	X			
Philosophy of Teaching	X	X		XX	X	

√ represents teacher's performance and X represents teacher's knowledge and beliefs. XX or √√ means that the teacher's knowledge/beliefs or performance in this domain are more dominant than X or √. No mark in a category means that the teacher did not demonstrate or express any aspect of knowledge/beliefs or perform any style of teaching in that domain.

rural, mid-western community of 2,500 people. The majority of his students were Caucasian. He had 60 male students and 68 female students. Don had about 20-30 students in his classes who were classified as having special needs. He had good rapport with his students. The student-teacher interactions in his classroom were cooperative. Most of the time his students appeared to be engaged and on-task.

Don showed a high degree of consistency among his knowledge, beliefs, and performance. His knowledge and beliefs turn out to be student-centered teaching style in most of the TPPI categories, except in teacher's knowledge and beliefs about view of science content, where he holds a conceptual teaching style as dominant. Also, Don holds some aspects of teacher-centered knowledge and beliefs about his teaching.

Don displayed student-centered teaching performance throughout his four videotaped lessons with some aspects of conceptual teaching. The summary of the analysis results for Don's knowledge, beliefs, and performance is included in Table 17.

Section Three: Kathy's Case study

Kathy Brown (a pseudonym) is a second year secondary science teacher in her upper-thirties. She was a biology major and chemistry minor. She graduated with a science degree in 1978 from a large mid-western university different than her teacher preparation university. Kathy worked as a medical technologist for a while and then she worked in health care using computers. Her areas of teaching certification are general science, biology, chemistry, and physical science.

Background

During her preservice teacher certification course work, Kathy took general chemistry and biology courses in college. Her chemistry training and experience includes five years as a medical technologist before going into science education, plus her courses in organic chemistry, qualitative analysis and lab, biochemistry, and biochemistry lab.

Kathy's background in math and physics included math through college calculus, and a full year of physics (one semester for physics majors; the second semester for health science majors).

Her pedagogical training in teacher education was in the MAT Program in South Global University.

Kathy could not remember if she had any field experience before she began student teaching in her general education courses. Her student teaching assignment included four life science sections for middle school level (6-8) and one biology section for high school level (9-12).

Teaching context

Kathy began teaching at Mejier High School (also a pseudonym) in 1995. It is a small school in a small city with a population under 25,000. Approximately, 40% of all local community residents in this town earned incomes of less than $40,000/year, and another 40% earned less than $70,000. The Mejier School system includes about 800 students in grade 9-12.

Kathy's teaching load consisted of five periods of 9th grade physical science each day plus one period college credit-biology. Kathy was assigned to several non-teaching duties including hall, bus, and cafeteria duties.

Most of her students were Caucasian. She had 75 male students and 71 female students. Kathy had 13 students in her classes who were classified as having special needs. She usually addressed their needs by working with the special education teachers who were supposed to help in mainstreaming. All of her students spoke English as their primary language.

Kathy had no computer in her classroom, and she used the computer lab less than twice per semester. Mostly, the computer lab was used for math and English remediation with some word processing. She had access to laser disc players, CD-ROMs, and a modem.

Kathy used a Physical Science text by Prentice Hall, (First Edition, 1988) in her classroom. She also, used supplementary materials, such as NSTA Mechanics, GEMS (it is a large set of science activities), and Cabbage Chemistry. Usually, Kathy spent 12 hours per week preparing to teach science.

Kathy used many methods of assessment to assess her students' understanding in science including group work, worksheets, discussion with students, essay/short answer, projects, oral reports, multiple choice tests, true/false tests, fill-in the-blank questions, homework, and lab write-ups.

Kathy is a member of National Science Teacher Association (NSTA). In the past year, she attended one national science teacher conference, but she did not present there.

She attended one workshop after school session on using a camera for a microscope for biology and biotechnology.

Kathy's Knowledge and Beliefs

Kathy's knowledge and beliefs were documented by using the Teachers' Pedagogical Philosophy Interview (TPPI). Her interview was audio taped, transcribed, coded, and analyzed. HyperRESEARCH software and coding protocol developed for the Salish Project were used in the process of coding and analysis. Most of her knowledge and beliefs turn out to be early constructivist and conceptual, with some aspects of didactic and transitional. The summary of the analysis of Kathy's knowledge and beliefs according to the TPPI supercodes is included in Table 18.

Teacher's View of Content

The coded interview indicates that Kathy's views of science content are both early constructivist and conceptual.

In her SIDESTEP questionnaire, Kathy listed the top three goals in order of importance that she holds for her students:

- "Students are honest and self evaluate themselves honestly about their effort in class and out of school.
- "Students view science as meaningful and important.
- "Students think critically about issues relating to the science and application of science that they have learned about."

Table 18: Analysis of Kathy's Knowledge and Beliefs

Area/ Knowledge & Beliefs	Didactic	Transitional	Conceptual	Early Constructivist	Experienced Constructivist	Constructivist Inquiry
Teacher's Views of Content			X	X		
Self as a Teacher				X		
Teacher's Actions	X	X	X	X		
Students' Actions		X	X	XX		
Environment				X		
Context	X					
Diversity			X			
Philosophy of Teaching	X		X	X		

She believes that students should see science as dynamic, not absolute truth, and as relevant to life. These teaching beliefs were part of her response to how she would like her students view science by the end of the year, she says:

> "Um, *it is really important to me that they [students] do not view science as absolute truth.* You know, it is just, I think, again, *it is important to illustrate that science is changing* and, um, it is self correcting and all that. I hate for them to think that it is everything. That it is absolute truth. Um, I really think *they need to see that science is involved in a lot of, um, issues and, um, that is the key to them seeing it as meaningful"* (TPPI Interview, 1995). [emphasis added]

Kathy thinks that content knowledge is important for students to learn, especially, the main concepts in each subject area. For example, she believes that the concepts of the cell, DNA, and chromosomes are the most important concepts in biology that her students need to understand. Also, she believes that her students can, "construct these ideas (concepts) in their mind through a learning process." So, Kathy believes that her students should understand these concepts and deal with a, "minimal amount of content they are going to use again and retain."

<u>Self as a teacher</u>

When Kathy was asked about what areas she would like to improve as a teacher, she said, she wants to learn more about teaching and learning with technology, because there are many computers in her school. Also, she wants to use this technology to demonstrate more hands-on activities that fit with her lessons and units. According to the TPPI super codes, this description would be coded under other. So, labeling these teaching beliefs with any of the primary teaching styles referred to in this study will not fit with her response. She believes that, "with technology ...we had some classes on Internet, we have Internet at school. So, there is really a lot, oh, there is just all kinds of things to be learned." So, for her the aim of learning how to use technology (i.e., internet) is to help her students interact with other students in or outside the school.

She believes that her main strengths are self attributes. For example, she sees herself as approachable, enthusiastic, and somebody the students can talk to. In the TPPI transcript (1995) when she was asked about her main strengths as a science teacher, she says:

> "I think they find me approachable. That is so important. If they really view you as somebody they can talk to, you know, that they can approach. That is really, really critical. Um, and to make yourself available to the students, um, because the classroom time is just never enough."

Teacher's Actions

The analysis suggests that Kathy's actions are didactic, transitional, conceptual, and early constructivist, in different areas of her teaching.

Kathy feels that what to teach is based on forces beyond the classroom, including following what has been taught in the past and what is in the textbook. She moves onto other concepts based on the required curriculum and the schedule, not because students understood the concepts.

Also, she decides what to teach based on student reactions and directions, current concerns in the society, or current areas of research. So, Kathy makes her decisions about teaching based on student' ideas, shares science examples with the students (i.e., real world connections), and benefits from research results. These teaching beliefs were clear in her response to how do you decide what to teach and what not to teach, as she says:

> "So a lot of it I really, um, go by what is, um, *current concern, a current concern in society or some order in a current area of research.* In biology, advanced

> biology this year, we hit DNA really, really hard because of the O.J. Simpson trial. And um, so *I think any time that is there is something outside the classroom that might help interest the students and show the relevance of it*, I think it is important to seize that opportunity" (TPPI Interview, 1995). [emphasis added]

Kathy maximizes students' understanding by using a variety of instructional activities in the classroom. In her videotaped lessons, she used lecture, demonstrations, hands-on, and lab stations[4].

She focuses on organization and classroom management in describing the well-organized classroom. Kathy wants to put more emphasis on classroom discipline than any thing else. So, she wants to form her model of a well organized classroom based on classroom management criteria rather than focus on students' learning, as she says:

> "Students should know what is expected of their behavior. That should be clear. There should be a fairly straight-forward routine as far as assigned work and due dates and late work. All that should not be a big deal every day and a hindrance. All that should be established pretty much at the beginning of the semester or year" (TPPI Interview, 1995).

<u>Students' Actions</u>

The coded interview indicates that Kathy's students' actions are transitional, conceptual, and early constructivist.

Kathy states that she knows that her students understand a concept through her use of written tests or students' display of skills through hand-on demonstration. She believes that learning is occurring in her classroom when students apply what they have learned, explain something, or discuss something. So, Kathy believes that her students are able to use their knowledge of scientific concepts and make connections and

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[4] Kathy mentioned that she used lab stations in her videotaped lessons, but were not observed by the writer.

applications as an indication that they understood these concepts.

Kathy accommodates students with special needs in her classroom by sending those students sometimes to the special education teacher who assigned for each student, or she makes more than one form of information for them to use. For example, she uses written, verbal, and representations/displays as different ways of reaching students.

Kathy believes that her students learn in different ways. She says, in response to a question asking how do you think students learn best:

> "I think it is a combination...I think by us having a combination of, um, ways to present the material or see the content or concept in the classroom. Again, *I think a lot of students are either visual, auditory, or kinesthetic learners.* You know, I think each of them, and then there are, of course, students with learning problems-we have dyslexic students" (TPPI, 1995). [emphasis added]

Her understanding that students would learn in different ways and her attention to meeting those learning needs by varying her instruction would place her in the early constructivist domain. Therefore, regarding students' actions, Kathy provides some evidence of beliefs that represent transitional and conceptual teaching styles but the major emphasis on the beliefs about students' actions is early constructivist.

Environment

She wants her class to be challenging in order to help her students gain self confidence. As she mentioned in her TPPI (1995) interview,

> "*The most important thing would be because she challenged me*. You know, I think that is really important. You know, if they had one project or one assigned or anything that they looked at and said, 'Oh, I just can not do that,' and if they really tried and they were able, you know, to progress in their learning, understanding, and then *as a result they gained a lot of confidence in their learning*, I think that would be pretty important." [emphasis added]

Kathy reports that she manipulates the physical environment inside her classroom to maximize students' understanding. So, she is changing the environment of the classroom and not focusing on students' learning (i.e., emphasis cooperative learning or use students' ideas) to maximize students' understanding.

Context

When Kathy was asked about, "What are some impediments that are you have faced in trying to implement the kind of teaching that you want in your classroom," she said she thinks that the lack of resources in her school is the most important impediment that she faced in trying to implement the kind of teaching she wants. For example, she said that she went through a huge battle just to try to get some microscopes. Also, she mentioned the lack of textbooks, especially advanced biology textbooks. However, her response was about school resources, and not to deal with her classroom learning context. According to the TPPI super codes, these teaching beliefs could place her in the didactic domain. Such a label is obviously a simplification.

Diversity

Again, Kathy recognizes that teachers should accommodate students with special needs by changing the instruction. She thinks that,

> "The best thing you can do is to have more than one form of information. You know, do not write everything on the chalkboard or the overhead. You know, do not just say everything. You know, a lot of times, you know when reading through summarizing something, asking questions, and then as well having something on the overhead to try to get different ways of reaching them" (TPPI, 1995).

It is interesting to note that her response to a question about diversity is about diversity of learning styles, not ethnicity or gender. Kathy's teaching beliefs would place her in the conceptual teacher domain in terms of her knowledge and beliefs about diversity in her classroom.

Philosophy of Teaching

The coded interview shows that Kathy's philosophy of teaching contains aspects of didactic, conceptual, and early constructivist views.

She sees herself as, “definitely a visual learner.” She knows that she learned something when she can remember that thing. Kathy differentiates between learning and knowing in terms of memory. She refers to learning as a short term memory event, while knowing results in long term memory. She believes that a good learner can listen to a lecture and see things (i.e., see transparencies). All these teaching beliefs would place her in the didactic domain, because she used the term “memory” to distinguish between knowing and leaning. She distinguishes based on the amount of scientific knowledge that has been accomplished and how long can learners save this knowledge, instead of saying that learning and knowing are similar and each one will lead to the other. Also, she focuses on listening and seeing as criteria for a good learner, instead of focusing on learners’ personality traits (i.e., curiosity, creative, or being a risk taker), or on development of understanding scientific ideas and learning.

Kathy believes she knows something when she can use that content knowledge and be able to solve problems in the real world. She thinks that she can learn very well by doing such as making a concept map. Also, Kathy believes that her students understand a phenomenon when they are able to explain it.

Kathy's underlying principles of teaching are revealed in the TPPI (1995) interview, as she says:

> "I think, the first thing that comes to mind is *the attitude of the student or learner.* Actually, I have met up with students, you know, that really do not want to learn. One of our administrators said during our orientation, there is nothing stronger than a made up mind, and I believe that. I think their attitude has so much to do with it....And another principle, again I feel so strongly that you have to take into account *individual learning styles* and, um, cater to those different learning styles as much as you can within the time frame you have...*I think responsibility*, you know, beyond your subject matter, moral responsibility. *I am trying to challenge these young people into becoming people that can hold jobs and be responsible.*" [emphasis added]

She also believes that learners have different learning styles and attitudes. These teaching beliefs reflect her being an early constructivist teacher in terms of her knowledge and beliefs about philosophy of teaching, because her teaching is focused on students, especially development of self esteem, students having different learning styles, and students having different attitudes toward learning science.

Kathy's & Her Students' Beliefs about the Learning Environment inside the Classroom

Kathy and her students' beliefs about the learning environment inside the classroom were measured using the Constructivist Learning Environment Survey (CLES). The maximum score for each sub scale is 35 and the minimum is 7. Kathy and her students' results on CLES survey are summarized in Table 19.

Contrary to beliefs of most teachers, Kathy's students see more relevance to her teaching than she does. Kathy's score on this sub scale was 22 and her students' was 26.8.

Kathy's score on the Scientific Uncertainty scale also is lower than her students' scores. This shows that she has a more absolute view of scientific knowledge than her

Table 19: Kathy's and Her Students' Scores on the Constructivist Learning Environment Survey (CLES)

CLES Sub Scales	Kathy's Score	National Sample: Science Teachers Mean Score n= 69	Kathy's Students Mean Score from One Class (n=26)	National Sample: Students Mean Score n > 5,000
Personal Relevance (PR)	22	24.8	26.8	23.3
Scientific Uncertainty (SU)	20	22.6	23.9	22.6
Critical Voice (CV)	23	No data available	24.7	24.3
Shared Control (SC)	16	20.8	15.9	17.2
Student Negotiation (SN)	24	No data available	23.4	22.6

students. The students tend to view science as involving activity embedded in a cultural context and embodying human values and interests while she believed that her teaching rarely or sometimes communicated science in this way. She scored on Scientific Uncertainty Scale (SU) 20, while her students scored 23.9.

Kathy and her students hold nearly the same beliefs about students' ability to exercise legitimately a critical voice about the quality of their learning activities. She scored 23 on Critical Voice Scale (CV) and her students scored 24.7. In other words, both Kathy and her students believed that students were able to exercise critical voice sometimes or often.

Kathy and her students also have nearly the same view on their perceptions about the control of classroom learning environment. They believe that students are seldom involved in the management of classroom learning. She scored 16 on Shared Control Scale (SC) and her students scored 15.9. This means that Kathy practiced teacher-centered method in her teaching, so the students did not have much input about the nature of their learning or make significant decisions about it.

Finally, both of them hold almost the same beliefs about the nature of student negotiation inside the classroom (i.e., the role of students inside the classroom). For example, Kathy and her students believe that student-student interactions for the purpose of building their scientific knowledge within the consensual domain of the classroom is sometimes or often important for students' learning. Her students' mean score on the Student Negotiation Scale (SN) was 23.4, while she scored 24.

Kathy's Teaching Performance

In the three consecutive days of teaching recorded in her video portfolio, Kathy taught "Fluid Pressure" for 9th grade students at Mejier High School. Before these three videotaped lessons, Kathy mentioned that she designed six different demonstrations to help her students understand the idea of fluid pressure.

On the first day, she asked her students to explain the demonstrations that they did the previous day on fluid pressure. For example, she asked them to explain why the Pepsi can [with water in it] collapses when it is cooled after heating? Why when you heat a glass bottle, will the egg fall down into the bottle when the heat source is removed? She listened to students' responses. There was no evidence that Kathy used students' responses (i.e., students' ideas or misconceptions) to guide her teaching. Kathy did not explain how these demonstrations are related to the fluid pressure. However, these demonstrations could not help students understand the main ideas in this topic, because each demonstration needs to connect few concepts to be understood. To understand these two demonstrations, students need to connect the following concepts together: force, area, internal pressure, atmospheric pressure, dynamic fluids, statics fluids, and pressure difference.

In another task, she was looking for an explanation of real world events. For example, she asked her students to explain how the pneumatic tube in a bank drive-through system works? To facilitate students' understanding, she asked them to work in small groups and report back to the class.

On the second day, she asked her students to work in small groups to design a boat to float in water. The idea of this activity as Kathy reported in her videotaped lesson was to figure out the relationships between mass, volume, and density of modeling clay in order to design a clay boat that will float in the water. So, the students need to change the shape of the clay so that it will float. However, the introductory part of this activity was not connected effectively to the main topic, fluid pressure, or to the "Archimedes' Principle." Kathy wrote, "Archimedes' Principle" on the blackboard without any explanation to this principle or discussion with students. No more analysis could be done on the second day lesson because the sound of the tape was disconnected for about 30 minutes (the researcher could not hear anything from the tape after the first sixteen minutes). However, the overt action of Kathy on her class suggests that she displays a student-centered style of student-teacher interaction.

In the last day, she reviewed the test questions with her students. The text of the test was about "Force and Momentum."

Overview

These three consecutive videotaped lessons were analyzed using the Secondary Teacher Analysis Matrix-Science Version. The STAM analysis of the video portfolio for Kathy's teaching performance is reported under several categories: overview; teacher's content; teacher's actions; students' actions; resources; environment; and other.

In her teaching the STAM analysis suggests that Kathy displayed teacher-centered teaching with of some aspects of student-centered and conceptual teaching. For more information, see Table 20.

Teacher's Content

The way that Kathy structured the content in lessons is mainly factoids with some aspects of explanatory mode. She often asked her students to recall information from previous lessons. Kathy spent some of the time (30%) on definitions of concepts. She asked her students to copy the definition of each concept from the transparency. In some cases she asked them not to do that because they could find the definitions in the reading package.

The connections among these concepts were not observed in Kathy's video portfolio. In a few cases, such as pumping water , hydraulic machines, pneumatic system examples and connections were made by the teacher, and sometimes were mentioned by students and the teacher. Students offered some examples for the applications of fluid pressure in their every day life. Kathy did not present the limitations, exceptions, or multiple interpretations of this topic. For example, in her lessons, it is essential to mention that fluids behave differently when they are at rest than when they are in motion. Fluid statics concentrates on the properties of fluids at rest, while fluid dynamics focuses on

Table 20: Video Portfolio Analysis of Teaching Performance for Kathy

Area/ Teaching Style	Didactic	Transitional	Conceptual	Early Constructivist	Experienced Constructivist	Inquiry Constructivist
Teacher's Content	XX	X	X	X		
Teacher 's Actions	XX	X	X	X		
Students' Actions	X	X	X	XX		
Resources	X	XX				
Environment	X					

fluids at motion (Cutnell & Johnson, 1995). Neither the history of science nor the process of science was mentioned.

Teacher's Actions

Kathy used some teacher-centered methods in her teaching, as well as some hands-on methods. These activities were either overly directed in which students followed the procedure in order to confirm the results, which students might already know or undirected such as exploration without specific follow up. For example, she asked her students to follow the instructions in the lab procedures exactly without changing anything to do one of the fluid pressure application experiments. There were few teacher-students interactions about subject matter in these lessons. The focus of interactions most of the time was on clarification of procedural issues. Kathy's questions focused on factual recall. For example, she asked her students to define some concepts like force and pressure.

She used tests and quizzes in her assessment. For example, she asked them to differentiate between force and momentum, mass and weight, define some concepts, and solve some mathematical problems in her test review. Her assessment process did not appear to go beyond grading. She focused on the grades and the right answer. The test appeared to be an end in itself to give grade, not a method to assess students' understanding and to guide her teaching.

Kathy accepted all students' ideas about subject matter. For example, one student said "at higher altitude air pressure increases." The student's prediction was wrong, in fact, the pressure decreases. Instead of helping the students rethink about his prediction, she asked another student to give the right answer without asking him for an explanation. By doing so, she stressed the factual nature of science.

Students' Actions

Many activities in the class often were done in small groups. In Kathy's teaching, writing and other representations of ideas were not used. She was looking for short answers. The nature of students' questions tended to be more procedural than conceptual. Student-student interactions about subject matter also tended to be more often about procedure than clarification. Students rarely volunteered examples or analysis, and when they did so, examples were weakly connected to the class activities. Students' showed confusion over procedure, particularly, when they were asked to follow procedure.

Resources

Kathy used a reading package and small number of other resources, including some hands-on activities. These resources appeared to have limited relation to the content being taught. Most of the time, Kathy controlled the access to these resources.

Environment

Many decisions in this class were made by Kathy. A few teaching aids were displayed which were not related to content (e.g. periodic table of the elements, skeleton). There was no evidence of students' work being displayed.

Other

The accuracy of content for Kathy was not a problem, because she was confident when she transferred the content to her students. In her videotaped lessons she provided evidence that she knows a lot of scientific facts that related with fluid pressure topic. The quality of student-teacher interactions was cooperative, but the focus of interaction was mostly about procedure. Usually, student were engaged and on-task, even though some students were playing basketball through the activities time. Transitions were well organized and naturally smooth. Use of the time was well organized. Facilities were flexible and changed frequently.

Summary of Kathy's Case

Kathy Brown is a second year secondary science teacher in her upper-thirties. She was a biology major and chemistry minor. She graduated with a science degree in 1978 from a different large mid-western university than her teacher preparation university. Kathy worked as a medical technologist for a while and then she worked in health care using computers. Her areas of teaching certification are general science, biology, chemistry, and physical science.

Kathy began teaching at Mejier High School in 1995. Kathy taught 9th grade physical science and college credit-biology at a small school in a small city. Most of her students are Caucasian. She had 75 male students and 71 female students. Kathy had 13 students in her classes who were classified as having special needs; none of them had English as a second language.

Kathy who graduated from SGU's teacher education program reflects inconsistency among her knowledge, beliefs, and teaching performance. Kathy's knowledge and beliefs turn out cover the gamete from teacher centered to conceptual to student-centered with emphasis on student-centered. Moreover, she displayed teacher-centered teaching performance with small degree of conceptual and student-centered

Table 21: Summary of Analysis Results for Kathy's Knowledge, Beliefs, and Performance

Area/ Knowledge, Beliefs, & Performance	Didactic	Transitional	Conceptual	Early Constructivist	Experienced Constructivist	Constructivist Inquiry
Teacher's Content	√√	√	X√	X √		
Self as a Teacher				X		
Teacher's Actions	X √√	X √	X√	X √		
Students' Actions	√	X √	X √	XX √√		
Environment	√			X		
Context	X					
Diversity			X			
Philosophy of Teaching	X		X	X		

√ represents teacher's performance and X represents teacher's knowledge and beliefs. XX or √√ means that the teacher's knowledge/beliefs or performance in this domain are more dominant than X or √. No mark in a category means that the teacher does not hold any aspect of knowledge/beliefs or perform any style of teaching in that domain.

teaching. The summary of the analysis results for Kathy's knowledge, beliefs, and performance is included in Table 21.

Chapter 5

THE LINKAGES AMONG TEACHERS' PERFORMANCE, KNOWLEDGE, BELIEFS, TEACHER PREPARATION PROGRAM FEATURES, AND TEACHERS' CHARACTERISTICS

This chapter describes linkages[1] among teaching performance of these four new high school chemistry teachers, their knowledge and beliefs, features of the teacher preparation programs they experienced, and their personal characteristics. This chapter begins with a brief summary of the most important findings followed by a more detailed delineation of those findings for the four teachers who are the subjects of the case studies presented in chapters three and four.

Again, in this chapter I used categories of teacher-centered, conceptual, and student-centered to describe high school chemistry teachers' knowledge, beliefs, and teaching performance as they are defined in the methodology chapter, chapter two.

After deep analysis of the four new high school chemistry teacher cases, it turned out that these teachers displayed teaching performance that differed in important ways. While all four teachers had student-centered aspects of their teaching, two of them had more teacher-centered aspects than others. One of them turned out to be a mix of teacher-centered and conceptual in his teaching performance. While, the fourth showed a mixture of conceptual and student-centered teaching.

The aim of this chapter is to answer the following questions which came out in the first phase of analysis:

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[1] "Linkages, "relationship," and "association" are used interchangeably in this chapter. The data were primarily qualitative. There is no claim or assertion of causality, nor should any be constructed, (Salish, 1997).

1) What kind of teaching performance was displayed by these four new teachers, and what knowledge and beliefs did they hold related to teaching?

2) Why did they teach the way they taught?

In order to gain better understanding, it is appropriate to answer question one by looking to the linkages for each teacher among their teaching performance, knowledge, and beliefs and then comparing the four cases to explain some of the investigated relationships. I can hypothesize about the answer to question two by looking to the linkages among the findings from question one, teacher preparation program features, and teachers' characteristics.

Summary of Major Findings

- **The course objectives in the teacher education programs at both institutions were diverse and more comprehensive than science disciplinary program course objectives.** The course objectives in science courses were almost entirely content-oriented in both institutions. These objectives were coupled with vast amounts of scientific information to be learned. However, the course objectives in the teacher education programs at both institutions were structured to help prospective teachers learn about constructivist teaching.
- **All four of the teachers and most of the faculty interviewed confirmed that the connections between prospective science teachers' learning and real world applications were not clearly addressed as a major goal in science courses at either institution.** This point was widely agreed upon. In addition, the prospective science teachers and the faculty members said that the connections between science

labs and lectures were weak and that the lab is primarily used to verify previously known facts or laws. Moreover, the prospective science teachers agreed that the connection between the lab and the lecture is essential to understand science concepts. Only one teacher took three or four of the applied courses available through his teacher education program (at SGU), and the other program (NGU) did not have such courses available. Steve and Terry took an elective course in their teacher preparation program (at NGU) that focused on teaching using laboratories in secondary science classrooms. They both identified this class as beneficial.

- **Prospective science teachers did not experience cooperative learning in their science classes.** They sometimes did work in groups in their labs, but these would not generally be described as cooperative groups. Otherwise, this experience with cooperative learning was limited to their courses in teacher education. All of the prospective science teachers reported that the primary method of instruction was cooperative learning in their science methods courses. However, in describing the nature of group work in the science education seminars, the director of education center at SGU said, "may be it is not exactly cooperative learning."
- **All new secondary science teachers reported that they used a variety of assessment methods in their science education courses.** The common assessment methods that they experienced were papers, interviews, presentations, projects, and student teaching. All of them practiced teaching in their science education courses before they became interns. Assessment in science courses was almost exclusively in the forms of mid-term and semester end objective tests that were machine scored.

- **All four of the teachers identified that learning from on-the-job experience or field experience in their teacher preparation programs was a crucial factor in developing their teaching approaches.** The teacher with the most consistency among knowledge, beliefs and performance rated his on the job experience as providing 80 percent of his teaching model. The graduates of NGU completed a year long student-teaching internship. All four teachers gave a very low rating (between five and 20 percent) to their undergraduate programs as contributors to their teaching models. One teacher who had thirteen years in a prior career did not identify any contribution from that career to her teaching model. The year long internship in the teacher education program at NGU was valued by Steve and Terry. This internship was both part of separate courses and integrated into existing courses. At SGU Don and Kathy had student teaching for one semester. During their student teaching, new secondary science teachers were required to teach in different levels through their science method courses. Steve and Terry found that having a professional secondary science teacher within the team of course instructors helped them to gain first hand experience that was closer to a real classroom setting. The benefit from this experience was influenced by several factors like school context and collaborating teachers. Terry and Kathy had their student teaching experiences in very difficult school contexts.
- **While all four of the secondary science teachers hold student-centered beliefs about teaching, only one effectively demonstrated student-centered teaching.** All four agreed that science should be taught in way that connects to students' lives. However, only one demonstrated teaching practice that reflected this belief. The

structure of the content of all four teachers is mostly descriptive and explanatory in the courses they taught. None of the teachers mentioned anything about the history of scientific ideas in their video portfolios, even though two of them took courses about history and philosophy of science as part of their teacher preparation programs. All of four of the teachers expressed that they use science as a way to solve problems. Three of the four identified students' understanding of applications of science as a major goal for the classes they taught, even though only two of the teachers took courses in applied science as part of their teacher education program. All of their beliefs reflect that they made their teaching decisions based on students' understanding of scientific concepts. Thus, there is not a clear pattern of relationship between new teachers' preparation programs and their actions as teachers. In the students' actions domain, the beliefs of the four teachers' were more consistent with their actions than in any other domain. All four of the teachers believe that teachers need to use a variety of teaching strategies to fulfill students' needs. They acknowledge that learners are diverse. All of them use group work in their teaching. In two of the cases from two different institutions, the teachers structured activities where students presented their work. Most questions asked by students were procedural in nature. Unfortunately, in most of the videotapes, students' comments were not clearly audible.

- **The new secondary science teachers did not reflect a deep conceptual understanding of the scientific concepts that they taught in their video portfolios.** This related to the nature of the science disciplinary courses they took as teacher candidates. College science courses did not result in deep conceptual teaching for these new teachers. All of the teachers experienced lectures in their college science classes. None of these classes were designed for teacher candidates, but included a wide range of future scientists, medical personnel, engineers, teachers, and students preparing for other fields. The new science teachers experienced a dichotomy between science process and science content. In most science classes, the lab was taught in a way that was poorly connected to the lecture. The size of the classes was large – some as large as 800 students. The objectives of the science courses were generally content-oriented.

Linkages among Teachers' Performance, Knowledge, and Beliefs

The linkages among teachers' performance, knowledge, and beliefs for these new high school chemistry teachers are illustrated in Figure 1. Terry, Steve, and Kathy frequently displayed student-centered beliefs and knowledge yet their performance leaned heavily toward teacher-centered teaching performance. They also infrequently demonstrated some aspects of student-centered teaching. Steve sometimes displayed conceptual teaching, while, Kathy infrequently demonstrated some aspects of conceptual teaching. However, Don turned out to be the only teacher who frequently demonstrated student-centered beliefs and teaching performance with less frequent demonstrations of aspects of teacher-centered teaching performance. Sometimes, he displayed a conceptual approach to teaching.

In contrast to the variation in teaching performance, as Figure 1 shows, all of them expressed primarily student-centered teaching knowledge and beliefs with some

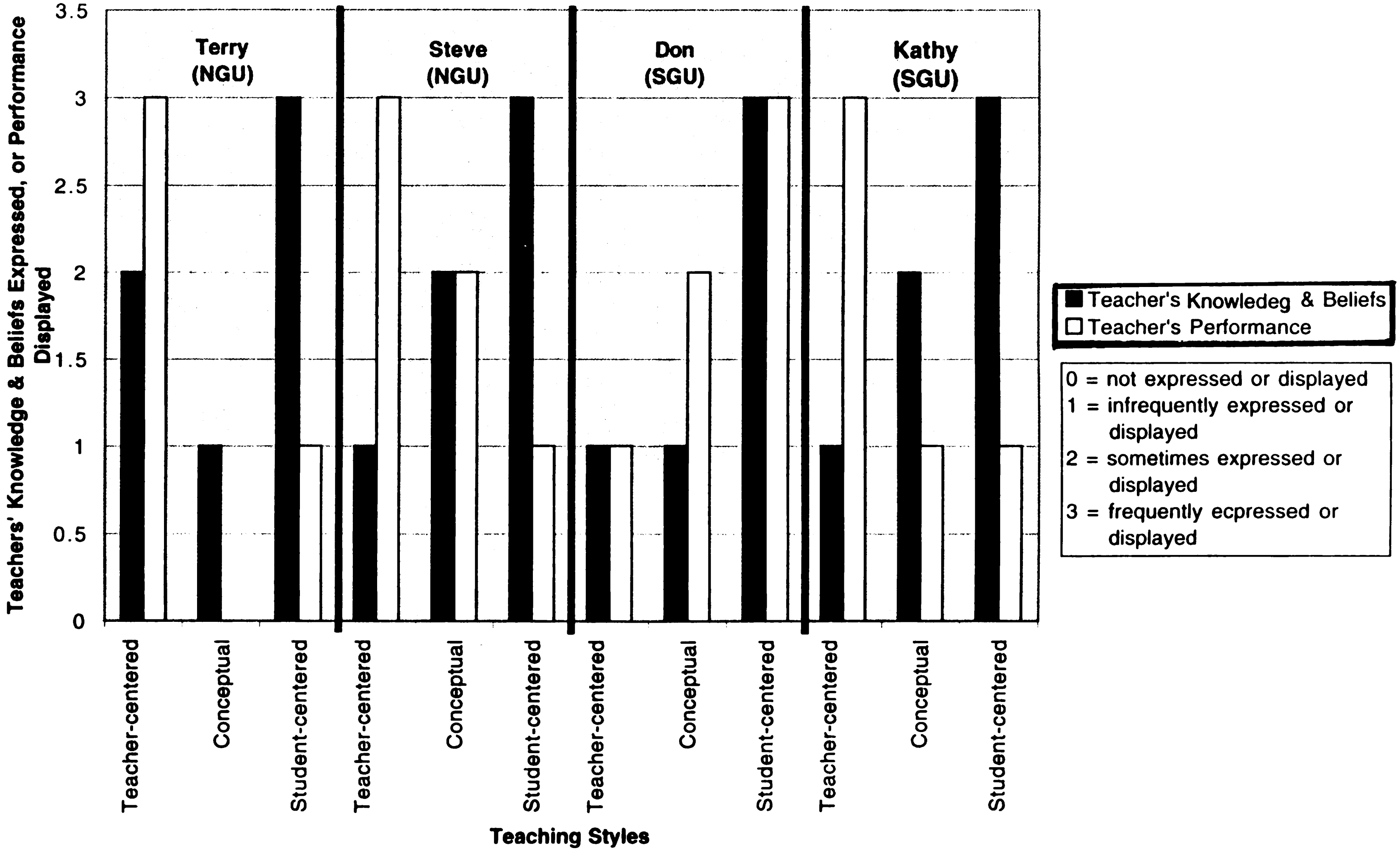

Figure 1: The Linkages among Teachers' Knowledge and Beliefs Expressed, or Performance Displayed

aspects of conceptual and teacher-centered beliefs. This is indicated by the dark bars in the figure. According to the TPPI supercodes, Kathy and Steve turn out to share a very similar distribution of classifications of knowledge and beliefs. Don expressed primarily student-centered beliefs, and he infrequently expressed some aspects of conceptual and teacher-centered beliefs. Terry sometimes expressed some aspects of teacher-centered teaching beliefs, and she infrequently expressed conceptual teaching beliefs.

Teachers' Performance, Knowledge, and Beliefs about Science Content

The linkages among these four new science teachers' knowledge, beliefs and performance in the science content domain are summarized in Table 22.

According to the STAM analysis of their videotaped lessons, the structure of the content for all of them is mostly descriptive and explanatory. However, Don and Steve provided evidence in their teaching that they structured the content in their science lessons around key ideas. In addition, Don and his students negotiated understanding of these key ideas with the teacher's content emphasized. Kathy stressed the factual notion of scientific knowledge.

In general, Kathy, Terry, and Steve offered a few examples in their teaching that integrated the subject matter. Their students offered some examples, too. However, these examples did not focus on students' understanding of the big picture of how these concepts connect to each other and how students can use this knowledge in their lives. In

Table 22: The Linkages among New Secondary Science Teachers' Performance, Knowledge, and Beliefs in The Science Content Domain

Domain	Terry	Steve	Don	Kathy
Knowledge and Beliefs	• Knowledge is conceptual. • Applications are essential.	• Knowledge is conceptual. • Applications are essential.	• Knowledge is conceptual. • Applications are essential.	• Knowledge is conceptual. • Applications are essential.
Performance	• Knowledge was factual. • Applications were limited. • Limitations and exceptions of science were missed. • Process of science was missed. • Example & connections made by teacher. • History of scientific ideas was missed.	• Knowledge was expressed in formulas. • Applications were missed. • Limitations and exceptions of science were missed. • Process of science was missed. • Example & connections made by teacher. • History of scientific ideas was missed.	• Knowledge was conceptual. • Applications were powerful. • Limitations and exceptions of science were missed. • Process of science was implemented. • Example & connections led by teacher. • History of scientific ideas was missed.	• Knowledge was factoid. • Applications were missed. • Limitations and exceptions of science were missed. • Process of science was missed. • Example & connections made by teacher. • History of scientific ideas was missed.

fact, these examples and connections that were represented on their videotaped lessons reflected the superficial relationships among these concepts and real world applications. For example, the relationships Steve discussed in teaching about the ideal gas law were only mathematical. He did not connect the gas law to real world examples in the lives of his students.

In contrast, all of them believe that the connections between science and students' lives are essential in teaching science. When they were asked, "How do you want your students to view science by the end of the school year?" Don said he wants his students to, "see how science applies to my [the student's] life." Kathy wants her students, "to see that science is involved in a lot of, um, issues and, um, that is the key to them seeing it as meaningful." Steve answered this question by saying, "they can relate it to something that goes on in everyday life." Terry, in her SIDESTEP questionnaire, reported that the second, in order of importance, of her top three goals that she holds for her students is, "to see science as a way of thinking applicable to every day."

It is noticeable that all of them agreed in their beliefs that science should be taught as a discipline related to students' lives (e.g., external applications of the science content knowledge, Cajas, 1998). However, in their practice, Don was the only one who made significant connections among the science concepts that he taught and real world applications. For example, he and his students diagnosed some of the X-ray films for different actual cases that showed bones broken in different positions.

None of the four teachers, through their videotaped lessons, provided any evidence that the limitations and exceptions of science content were addressed. In other words, no one mentioned when, how, or where we can or can not apply specific kinds of scientific knowledge (i.e., ideas, laws, and theories). For example, Kathy did not mention in her fluid pressure lesson where and when we can use these physical pressure laws (i.e., she did not differentiate between two kind of fluids: statics and dynamic). Also, Steve failed to mention that in reality there is no such thing as an ideal gas that obeys the equation perfectly under all circumstances. However, a fundamental fact is that all real gases deviate slightly from the behavior predicted by the law.

None of the four teachers mentioned anything about the history of scientific ideas in their teaching. Furthermore, the process of science was absent from Kathy's, Terry's, and Steve's teaching. Don integrated science process into his teaching. For example, Don and his students used the laser beam to derive the laws of reflection and refraction). By doing so, Don lead his students to reconstruct how evidence has been used to formulate scientific ideas and to use this process to formulate and evaluate ideas. However, it is important to note that Don ignored important issues dealing with laser safety in this lesson.

Steve's, Terry's, and Kathy's beliefs suggest that they value problem solving in science (i.e., science process) but it is not represented to any great degree in their teaching. For example, Steve thinks that one thing he needs, "to concentrate more on is getting them to problem solve instead of me taking the responsibility of problem solving." For, Terry science is, "basically inquiry ...to figure out the world around you through a defined method." Kathy also states that while students are involved in problem solving, she would like to have her students do more work, "where they have to solve problems."

However, while Don did not mention that quite so explicitly in his interviews, he reported in his SIDESTEP questionnaire that the second of his top three goals in order of importance that he holds for his students is, "to be able to begin to think logically and work problems out step by step."

According to their beliefs, all four of the teachers expressed that they used science as a way to solve problems (i.e., problem solving techniques), not as a process to understand the scientific ideas through problem solving (i.e., science is inquiry oriented). However, Terry mentioned that science is inquiry in her TPPI interview, but when she explained that she refers to it as a "defined method." So, following the scientific method does not necessarily lead to solving complex problems or to fostering students' understanding.

Therefore, in general, the matching between what they believed and what they displayed about science (i.e., science content and process) was not strong, because all of them except Don demonstrated the descriptive notion of science. In other words, they (Steve, Terry and Kathy) demonstrated science as two separate components, "science content" and "science process." Their comprehension of science process was limited or poorly integrated. It was evident through the videotaped lessons that Don sometimes integrated science content and science process.

<u>Teachers' Performance, Knowledge, and Beliefs about Teacher's Actions</u>

The linkages among these four new science teachers' knowledge, beliefs and performance in the teacher's actions domain are summarized in Table 23.

Table 23: The Linkages among New Secondary Science Teachers' Performance, Knowledge, and Beliefs in The Teacher's Actions Domain

Domain	Terry	Steve	Don	Kathy
Beliefs about Teacher's Actions	• Should be student-centered. • Should use a wide variety of assessment methods. • Students are diverse learners.	• Should be student-centered. • Should use a wide variety of assessment methods. • Students are diverse learners.	• Should be student-centered. • Should use a wide variety of assessment methods. • Students are diverse learners.	• Should be student-centered. • Should use a wide variety of assessment methods. • Students are diverse learners.
Observed performance in teacher's actions	• Attempted student-centered approach but was limited by student behavioral problems. • Lab demonstrations were absent. • Most teacher-student interactions were on classroom management. • Limited number of assessment strategies and procedures. • The focus of assessment was on grading.	• His action was divided between teacher-centered and conceptual approaches. • Lab experiment did not connect to the main topic. • Most teacher-student interactions were on solving mathematical problems. • Limited number of assessment strategies and procedures. • The focus of assessment was on grading.	• Exhibited student-centered & conceptual approach. • Demonstrations were conceptually focused. • Many teacher-student interactions were on students' ideas. • Multiple form of assessment strategies and procedures. • The focus of assessment was on students' ideas.	• Exhibited teacher-centered approach. • Class activities were cookbook. • Most teacher-student interactions were on clarification of procedures. • Limited number of assessment strategies and procedures. • The focus of assessment was on grading.

According to the video portfolio analysis, Terry and Kathy displayed very similar teaching performance in terms of their actions inside the classroom. Their approach was teacher-centered with some aspect of student-centered teaching styles. Steve's teaching performance, in terms of his actions, was divided between teacher-centered and conceptual with some aspects of student-centered teaching styles. Don displayed student-centered and conceptual teaching styles in terms of his actions inside the classroom.

However according to their beliefs, all of them expressed student-centered teaching beliefs about their actions inside the classroom. In addition to that, Steve, Terry, and Kathy expressed some aspects of teacher-centered teaching beliefs. Also, Kathy's beliefs suggest that she holds some aspects of conceptual teaching beliefs about her actions inside the classroom.

On the STAM-Science version, the teacher's actions domain consists of the following categories: methods; labs, demonstrations, and hands-on; teacher-student interactions; teacher's questions; kind of assessment; assessment use beyond grading, and teacher's responses to students' ideas.

All of them used teaching teacher-centered method with some aspect of student-centered. Small groups were used as an instructional strategy in their teaching. However, the quality of group work did not match with the actual meaning of "cooperative learning."

Don used many demonstrations that were conceptually focused (for example, UV, laser, microwave, x-rays, and etc.), e.g., he used the laser beam to demonstrate the laws of reflection and refraction. Kathy's activities were "cookbook," i.e., students went through procedures in order to confirm the results. Labs, demonstrations, or hands-on activities were absent from Terry's teaching on these three video taped lessons. Steve focused on solving mathematical problems. The experiment demonstration that he did was not clearly connected to the main topic of his three videotaped lessons (ideal gas).

The nature of teacher-students interactions varied. In Don's case, the focus of teacher-student interactions was on the clarification and usefulness of students' ideas. Both teacher and students had input (e.g., constructing the scoring rubric table). In Kathy's teaching the focus of interactions most of the time was on clarification of procedural issues. Steve interacted with students by showing them how to use the formula. Terry's teaching through the videotaped lessons indicated that there were few interactions between her and her students about subject matter.

The focus of the teachers' questions also varied. Don's questions focused on concepts and connections with some questions emerging from students' ideas and some from instructional objectives. Kathy's questions focused on factual recall. For example, she asked her students to define some concepts like force and pressure. Steve's questions were about the recognition of how to apply the formula, and end of the chapter problems from the textbook. Terry's questions were not directed toward either scientific knowledge, or factual information. Most of the time questions were used for classroom management.

Terry, Steve, and Kathy used tests, quizzes, and homework in their assessment as common assessment methods. In addition to that, Steve and Terry used journals. For example, Steve asked his students to draw a "concept map" for the chemical concepts that they learned at the end of each lesson. Also, Terry asked her students to design a commercial about 'energy transformations and applications." However, Don used multiple forms of assessment. For example, he asked his students to design a poster, pamphlet, page of a book, or a transparency that reflected their scientific understanding of the magnetic spectrum topic. Both the activity in Don's class where students developed materials and the activity in Terry's class where students developed commercials allowed the students some freedom in designing their classroom activities. However, Don used this activity as a tool to focus on students' misconceptions and students' learning. There was no evidence that Terry did that in her videotaped lessons.

For all of them except Don, the use of assessment was mostly on grading and checking on students' knowledge. For example, Kathy asked her students to differentiate between force and momentum, mass and weight, to define some concepts, and to solve some mathematical problems. However, Don and his students used the assessment in addition to grading to adjust activities (e.g., constructing the scoring rubric table).

The coded interviews of all four teachers suggest that they hold primarily students-centered teaching beliefs in term of their actions inside the classroom. Don, Terry, and Steve decide to move from one concept to another in teaching science, when they believe their students understand the concepts that have been covered. For example Steve could move to other concepts when most of his students, "have a mastery of [most of] the concepts." Kathy tries, "to have a lab for each main concepts in a unit and, um, then some discussion and review." It is clear from their expressed beliefs, that all of them believe they made their teaching decisions about when to move from one concept to another based on, "students' understanding," which suggest student-centered teaching beliefs.

When these prospective science teachers were asked, "How do you decide what to teach and what not to teach?" Steve and Terry decide what to teach based on the state objectives that influence their teaching. Kathy's teaching is sensitive to the students' reactions and directions, current concerns in the society, and current areas of research. Don tries to, "teach things that are, not only interesting to our students, but interesting to me."

Table 24: Assessment Methods Listed by Prospective Secondary Science Teachers in Their SIDESTEP Questionnaires

Teacher/Assessment method	Terry	Steve	Don	Kathy
Group work	√[2]	√	√	√
Worksheet	√		√	√
discussions	√	√	√	√
Essay/short answer	√	√	√	√
Project	√	√	√	√
Oral report	√		√	√
Homework	√	√	√	√
Lab write-up	√	√	√	√
Performance exam			√	
Concept map	√	√		
Student developed protocol		√		
Participation	√			
Fill-in-the blank questions				√
Quizzes from the curriculum	√	√		
True/false test				√
Multiple choice test	√			√

[2] √ Means that teacher lists this assessment method in his/her SIDESTEP questionnaire. Absence of a mark means the teacher does not use that kind of assessment in her/his teaching.

Table 24, derived from their SIDESTEP questionnaires, indicates that all of them share the following methods of assessment to assess their students' understanding in science: group work, discussion with students, essay/short answer, projects, oral reports, homework, and lab write-ups.

In contrast, their teaching performance through the videotaped lessons did not indicate that variety of different assessment methods to appraise students' understanding. For example the use of tests and quizzes was common in their videotaped lessons, but other kinds of assessment were uncommon.

Teachers' Performance, Knowledge, and Beliefs about Students' Actions

The linkages among these four new science teachers' knowledge, beliefs and performance in the students' actions domain are summarized in Table 25.

In the students' actions domain, the beliefs of the four teachers' were more consistent with their actions than in any other domain. Terry, Kathy, and Don expressed student-centered teaching knowledge and beliefs, and displayed student-centered teaching performance, too. However, Terry and Kathy displayed some aspects of teacher-centered teaching. Steve displayed conceptual teaching, while, he expressed conceptual and student-centered teaching beliefs.

In Don's class, students frequently used writing and other representations of ideas to construct meaning to their understanding of the main concepts. This was clear when Don and his students set criteria to judge students' assignments. In Steve's and Terry's classes students represented their ideas in writing as reconfigurations of textbook information or information provided. For example, Terry's students used their textbook

Table 25: The Linkages among New Secondary Science Teachers' Performance, Knowledge, and Beliefs in The Students' Actions Domain

Domain	Terry	Steve	Don	Kathy
Beliefs about students' actions	• Should be student-centered. • Students able to solve problems. • Students need to work in small groups. • Acknowledge students with special educational needs.	• Should be student-centered. • Students able to solve problems. • Students need to work in small groups. • Acknowledge students with special educational needs.	• Should be student-centered. • Students able to solve problems. • Students need to work in small groups. • Acknowledge students with special educational needs.	• Should be student-centered. • Students able to solve problems. • Students need to work in small groups. • Acknowledge students with special educational needs.
Observed performance in students' actions	• Student-centered. • Student worked in groups. • Students' questions were procedural. • Student-student interactions about subject matter were rare. • Students were frustrated by teacher's expectations. • Students rarely initiated activities.	• Student-centered & conceptual. • Students worked in groups. • Students' questions mainly were procedural and conceptual. • Student-student interaction were about correctness of answers. • Students accepted teacher's expectations.. • Students rarely initiated activities.	• Student-centered. • Student worked in groups. • Students' questions were mainly conceptual. • Student-student interactions were about understanding. • Students were frustrated by teacher's expectations. • Students contributed examples and analysis.	• Student-centered. • Student worked in groups. • Students' questions were procedural. • Student-student interactions were about procedure. • Students were frustrated by teacher's expectations. • Students rarely initiated activities.

as a main source from which to extract information to design their commercials. In Kathy's teaching, writing and other representations of ideas were rare, and she was looking for short answers.

In contrast, Kathy believes that her students can understand concepts, "where they have to write something, an explanation." Also, Steve believes that students can demonstrate understanding of the science concepts by using writing, "If they can write about it." However, while Steve used writing in his teaching, the focus mainly was on mathematical problem solving.

The nature of students' questions in Terry's class was procedural. Kathy and Don's students' questions were occasionally procedural and mainly conceptual. Steve's students engaged mainly in procedural and some conceptual questions, and they asked questions about how to solve problems, (i.e., how to apply the equation).

General speaking, the student-student interactions were not easy to hear because most of the time the camera was not moving and focused on teacher. So, there were not many interactions among students that you can hear very well. For example, in Don's class, student-student interactions about subject matter were not observed on these four consecutive lessons. In the other classes, student-student interactions were rare. The nature of these interactions was about procedure and clarification in Kathy and Terry's classes, while in Steve's class the focus was more often on the correctness of their answers. However, I made a speculation about Terry's class based on the students' group presentations that there was some student-student interactions about procedure and some about understanding.

In Steve's, Terry's, and Kathy's classes, students rarely initiated activities, they contributed few examples, and connections of these examples to class activities were weak. Don's students contributed examples and analysis, and most of these examples were appropriate.

All four of the teachers believe that the teacher needs to use different teaching strategies to fulfill students' needs. They acknowledged that learners are diverse. They recognize that there are students with special needs in their classes. They expressed different ways of dealing with those students' needs. Some of them want to change the physical environment in their classrooms (Don and Kathy). Others want to make changes in expectations (Don and Steve want to make changes in the assessment process; Kathy and Terry use different ways to reach them), and cooperate with the special education teacher or resource center in the school (Kathy, Steve, Don).

When the prospective secondary science teachers were asked, "how do you know when learning is occurring or has occurred in your classroom?" Steve and Terry made this determination from students' feedback. Don and Kathy were more specific as to the kind of student feedback (through project or small group discussion).

Linkages among Findings from Question One, Teacher Preparation Program Features, and Teachers' Characteristics

In this section the study is designed to investigate the linkages among the findings from question one, teacher preparation program features, and teachers' characteristics. The main features of science program and teacher education program in the three domains: content, teacher's actions, and students' actions are summarized in Table 26

Table 26: The Program Features in Science Content Courses & Teacher Education Courses

Science Content Courses	Teacher Education Courses
Content	
• Large body of content	• Less is better
• Very limited process knowledge	• Focus on process knowledge
• Poor integration within &across fields	• Integration is not clear
• Limited applications and not related to students' world	• Applications are important and related to students' world
• Lab frequently is not connected to the lecture	• Hands-on activities are connected to the lecture
• Course objectives are content oriented.	• Course objectives are diverse.
• Textbook, lab, recitation	• Multiple instructional resources
Teacher's Actions	
• Teacher-centered approach	• Student-centered approach
• Lecture	• Interactive
• Limited assessment strategies	• Variety of assessment strategies
• Test and checking on students' knowledge	• Assessment to guide learning
• Not part of faculty interest	• Encourage professional linkages
• Cooperative learning is missing, except in the labs	• Cooperative learning is common, especially in science methods courses
Students' Actions	
• Student passive	• Student active
• For all science majors & pre-mid	• For prospective teachers
• Students construct meaning	• Memorizing
• Large classes	• Small classes
• Informal but not strong with faculty members	• Informal personal relationship with faculty members
• No field experience	• Actual field experience (i.e., teaching)
• No cohort	• Informal & formal cohorts

When prospective secondary science teachers were asked, "in reference to the teaching model or teaching package that you have developed…if you had to divide that up into pie chart, how much of that chart would come from undergraduate training, graduate training, your on-the-job experience, or anything else that you can think of?" Their responses are represented in pie charts shown in Figures 2-5.

Don believes that most of the contribution (80%) to his teaching approach comes from on-the-job experience[3]. Terry credits on-the-job experience with 45%, Steve with 35%, and Kathy with 30%. The second most recognized contribution factor was the graduate training programs that include the internship year. Both Don and Kathy were graduates of the MAT program at SGU. Both Kathy and Steve believe that graduate work contributes 40% to their teaching models. Terry thinks that her graduate training contributes 20% to her teaching model, and Don 15%.

All of them believe that their undergraduate training did not contribute that much into their teaching approaches; this factor contributes between 5%-20%. Terry thinks that life contributes to her teaching approach 25%. Steve believes that science conferences, reading, and journals (professional events) contribute to his teaching package about 5%. Kathy believes, "workshops you've attended. Things that you've done outside of any classroom. Um, places you've gone. Reading you do at home...educational, things you watch on TV," contribute to her teaching approach approximately 10%. She referred to these contributions as "miscellaneous."

However, Kathy (who had 13 years prior career as medical technologist and health care data processing consultant) does not mention any contribution of that experience in her teaching approach. But in her NTI she reported that she used some of real world examples from her prior career experience in teaching biology.

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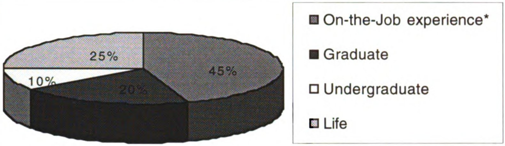
[3] When we read this we need to remember as I mentioned in the methodology chapter that the 2nd year of teaching for NGU graduates who participated in Salish Study was a first year of teaching that they got paid for. For SGU it was a 2nd year of paid teaching.



* Terry mentioned on-the-job experience twice in answering this question, keeping track of her total as she answered. She first stated that on-the job experience, "would be like 25%" As she finished her image of the pie, she said, "And then on-the-job stuff would be, like, the other twenty." It seems unlikely that she intended to count the job experience twice.

Figure 2: Factors Identified by Terry that Contribute to Her Teaching Approach (NGU)

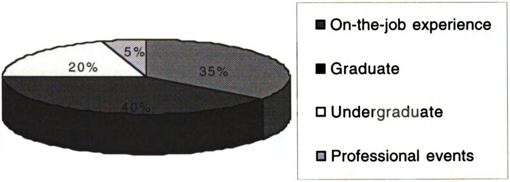


Figure 3: Factors Identifieid by Steve that Contribute to His Teaching Approach (NGU)

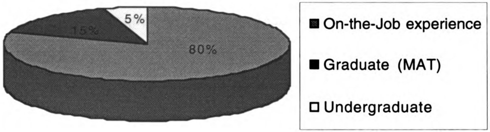


Figure 4: Factors Identified by Don that Contribute to His Teaching Approach (SGU)

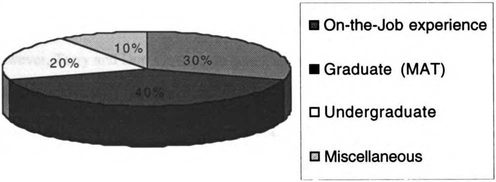


Figure 5: Factors Identified by Kathy that Contribute to Her Teaching Approach (SGU)

To address some of these linkages in depth, I divided this section into two parts. The first one, focuses on linkages among findings from question one, science content program features and teachers' characteristics. The second part focuses on linkages among findings from question one, teacher education program features and teachers' characteristics.

Linkages among Findings from Question One, Science Content Course Features, and Teachers' Characteristics

The study found that the match between Steve and Kathy's knowledge and beliefs, and their teaching performance about science was not so strong. Steve mostly displayed teacher-centered teaching performance with some aspects of conceptual teaching style, while his knowledge and beliefs turned out to be student-centered with some aspects of teacher-centered. Kathy displayed teacher-centered teaching style and expressed conceptual and students-centered teaching beliefs about science content. However, Terry and Don showed more consistency between their knowledge and beliefs, and their teaching performance. Terry displayed and expressed teacher-centered teaching styles. Don displayed conceptual and student-centered teaching performance, while he expressed conceptual teaching beliefs. However, he did infrequently display and express some aspects of teacher-centered approaches.

All of the teachers were taught science in large university classes. Mostly, the audience of these classes were all science majors (i.e., pre-medical majors). Steve and Terry had one class that was designed to help prospective secondary science teachers to reflect on their learning of some science content. The science lab (ASC 409) covered topics in physics, chemistry, and biology. Don took some classes that were designed for teachers and taught within teacher education program at SGU. This program offers classes in applied sciences. For example, within this program they teach applied courses like chemistry, biology, physics, earth science, and STS (Science, Technology, and Society).

All of the four new science teachers agreed that the objectives of the science courses that they experienced in the science disciplinary departments were content-oriented. Instructors delivered most science content to their students by using "lecture" as the most common instructional strategy in their teaching. As Jean[4] reported in her interview, the introductory chemistry course at NGU, "is designed to teach the traditional objectives of general chemistry."

The new teachers believe that these science classes taught at both institutions (NGU & SGU) covered too many topics, ideas, and concepts. For example, Steve described a typical science course that he experienced at NGU by saying, "It was pretty content-intensive…[they were] trying to cover as much material as possible." Don reported almost the same thing when he described his typical science class that he experienced at SGU by saying, "It was pretty much…cram as much stuff in your brain as possible." Terry added more to that by saying, "It was to get science content into your head, or science skills, or um, an attitude about science."

Kathy who graduated in 1978 with a biology major and chemistry minor, reported that the objectives of science classes were, "basic background knowledge." She also felt

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[4] Jean is a faculty member with a dual appointment between the colleges of education and science who studied the introductory chemistry course.

that it was unnecessary to attend some of the science classes because she, "could pretty much use the book and teach [her] self kind of out of the books."

This view toward science course objectives was confirmed by some of the science faculty at SGU. One of them said that the objective of his college physics course, "is to give the students an overall picture of physics from Newton down to the most modern development of what physics is all about or what it has been all about." Another biology instructor who taught a two semester course (plants and animals) said that the primary objective of this course is, "to give students foundation in all aspects of biology." However, the general chemistry course instructor, reported that the primary objective for his course was focusing on, "the basis for a physical model for understanding how molecules work."

Delivery of that much information within a certain period of time (e.g., one semester or two) influenced the way by which these courses taught. To cover as much content, science instructors were perceived as teaching these concepts as separate from each other. The complexity of the existing relationships among these concepts was perceived as absent from their teaching. However, the focus was on the superficial relationships among these concepts. Usually, in these science classes the connections among relationships were represented in mathematical formulas. This is especially true in chemistry and physics courses where instructors focus their teaching on these mathematical formulas and how to solve problems from a mathematical point of view, instead of teaching for conceptual understanding. While these are powerful ways to show connections, in the minds of professors, their meaning did not carry over to the new teachers.

Moreover, the connections between prospective science teachers' learning in the science disciplinary departments and real world applications were not strongly addressed as a major goal of teaching science at either institution. Only one chemistry instructor at SGU reported that the objectives of a course [chemistry XIX] were more "practical applications", as he says:

> "[The Chemistry XIX] course is more oriented toward the technical features, what chemistry does for us, what chemistry does for society, how chemistry help us to provide energy sources, provides material that are useful for building buildings, for cement for example, ceramics, semi-conductors" (Preservice Program Interview-Science Faculty Form, 1996).

Science in these science courses was taught as two separate components; science content and science process. The integration between these two parts of science was not addressed strongly in these courses. More importantly science process was not a well developed component of science courses, and it is remote from new teachers' comprehension (Gallagher, 1991). Students were rarely offered chances to explain, predict, and interpret data in order to construct their own understanding in these typical science classes, because instructors were concerned about class size, time, amount of content, and etc.

To make this kind of integration it is important to connect between the lab and the lecture. Furthermore, the lab should be designed as an inquiry to precede the lecture (Drwin & Pestel, 1992). However, labs and lecture were not well integrated at either institution. However, there were some exceptions. When new secondary science teachers were asked, "What science courses or experiences stand out in your mind as particularly important to you and why?" Steve response's was, "it seemed like the lab tied into lecture part of class instead of being completely separate." Terry liked her physical chemistry class and Don liked his astronomy class, because the instructors covered a lot of demonstrations in these two classes. In addition, Don liked his endocrinology lab more than lecture because he did some experiments on rats. For example, he did work, "kind of close to kind of research," to test the effect of hormone injection on rats.

All four teachers agreed that the association between the lab and lecture is essential for them to understand main ideas, concepts, and the relationships among them in any science discipline. In Don's science program, he experienced three or four of these courses and felt that he learned a lot from them. He said, "...there was a lot of learning in there [labs] I think than probably... lectures." However, Steve and Terry, who graduated from NGU, did not experience many courses that fulfilled their scientific needs. For example, Steve reported that he did not experience the tie between the lab and the lecture, "...in most science classes [he] had," in order to help him, "link ideas between the two." Also, Terry says:

> "The labs I took at [NGU] were also important. *I learned techniques to use the lab and learned some concepts as well* [in the lecture] (unfortunately) *the lab didn't always correspond with the courses"* (NTI, 1996). [emphasis added]

When new secondary science teachers were asked, "How often were cooperative learning techniques used in your science content courses?" Terry, Steve, and Don reported that they experienced cooperative learning techniques in their science programs only in science labs. For example Don said, "in most [science] classes not at all. Except for like in the labs." Terry said, "...in the labs, most of the time...in the lecture halls, never." Steve, said, "I guess in the lab sections...there was some sort of cooperative learning...I'd say forty percent of the time."

However, they did not experience the real nature of the cooperative learning process (i.e., not all group members were involved in the process of constructing their understanding as a group). In fact, they mostly experienced working with a lab partner and/or within small groups. The nature of the group work was mostly collaborative, instead of cooperative. Usually students divided the work among them[5].

For example, one of them would be responsible for running the experiment and collecting data; another would prepare solutions; a third one would do the calculations. If there is a write-up on the lab, it is most common that students will divide the work among them in the same way. It appears that the reason for the collaboration among students in labs is to reduce the time and effort, rather than to enrich the quality of the learning that comes from interaction over ideas.

Again as mentioned before, Don mostly displayed conceptual and student-centered teaching performance, while he expressed conceptual teaching beliefs. This study found other factors that related to Don's background that could contribute to his knowledge, beliefs, and performance about his science content teaching style. In his interview (NTI, 1996), Don reported that he likes physics because,

> " ...there was a lot of math involved in it and [he likes] figuring out mathematical problems...physics had a lot of good, um, demonstrations,...[he] always enjoyed helping [in the demonstrations]."

This quote reflects additional aspects relate to Don as a person, not with the science program content courses that he experienced. First of all, Don has a positive

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[5] These notes are reported by my own observations as a chemistry lab instructor and coordinator for two introductory chemistry lab courses in one of the residential science department at NGU.

attitude toward physics which most of the new non-physics major teachers do not have. Don had a biology major and chemistry/physics minor. As we know, science educators and scientists agreed that it is essential to have positive attitude toward the subjects that you teach. Second, Don loves to do mathematical problems this might facilitate his understanding of the physics content. I am not arguing here that would help him to transfer this knowledge to his students, but it is an important prerequisite to have a good background in mathematics in order to understand physics, based on the way physics has been taught in the university courses. Finally, Don is a curious person who is willing to help, ask, and do actions.

So, when Don had the freedom to videotape any three consecutive lessons, his choice was a physics topic. However, Terry and Steve chose to videotape classes in which they did not have a strong background in the science content. For example, Steve had less confidence in his chemistry background and he taught ideal gas law; and Terry had less confidence in physics and chemistry and she taught energy transformations and applications.

Linkages among Findings from Question One, Teacher Education Course Features, and Teachers' characteristics

Generally speaking, the study found that the objectives in the teacher education courses at both institutions (NGU & SGU) were diverse and more comprehensive than science disciplinary course objectives. For example, the course objectives of general education courses at SGU were broad. These courses were designed to provide prospective teachers with an overview of educational theories and philosophy, discuss students' needs, and model a variety of teaching methods and strategies.

Kathy and Don confirmed the broadness of these course objectives. For example Kathy said, "it may serve a purpose in kind of, kind of briefing you to what education as a broad field is all about." However, Don reported that these courses did not help him that much in his teaching. For Don these courses, "were pretty boring to me. I didn't look forward to them much."

At NGU the objectives of general education courses were broad, too, but the focus was mainly on teaching and learning to diverse learners in diverse context. For example, the course goals and objectives for [TE250] were the,

> "...examination of American diversity and it social consequences...look at the variety of effects that diversity has on schools, and that schools have on the diverse array of students attending them...examine the link between equality and number of social characteristics...look...ways in which educators and citizens can reshape schools" (TE250 Course syllabus).

The objectives of science education courses in both institutions were more specific toward teaching and learning science. The faculty members, Don, and Kathy agreed that the primary goal of science method courses at SGU was to provide prospective science teachers with knowledge based on research. In other words, the primary goals for these courses were to reduce the gap between theory and practice, or to transfer theory into practice. In addition to these objectives, the faculty members mentioned constructivist teaching and STS.

Steve and Terry agreed that the common objectives for science education courses at NGU were based in developing attitudes regarding education as a profession and science for all. As Steve said, "they [faculty] tried to instill in us that it [education] was a profession." In addition to these objectives, the faculty members described a wide range of teaching objectives reflecting a constructivist orientation.

The study found that the teachers' performance, and their knowledge and beliefs about their actions inside the classroom were not a close match, except for Don. All of them expressed mostly student-centered knowledge and beliefs about their actions inside the classroom, while their teaching performance ranged from teacher-centered to student-centered. Terry and Kathy mostly displayed teacher-centered teaching performance styles in terms of their actions. Steve demonstrated both teacher-centered and conceptual; Don displayed both conceptual and student-centered teaching performance styles. This may be the result of greater emphasis in science education courses on developing the contemporary vision of science teaching contained in National Standards and insufficient emphasis on developing the skills to implement this vision.

All four prospective science teachers reported that they used a variety of assessment methods in their science education courses. For example, the common assessment methods that they experienced in their science education courses were papers, interviews, presentations, projects, and student teaching. In addition to that, Terry and Steve reported that they wrote journals often in their science education courses.

All of them practiced teaching in their science education courses before they became interns. Terry and Steve had about 90 hours of classroom experience at the high school levels before they became interns. Terry and Steve had such experiences that in TE301, TE401, and TE402. Steve to some degree admitted that these courses were helpful for acquiring teaching experience.

Don and Kathy had more than 130 hours of field experience through science methods courses (I, II, III). However, Kathy could not remember if she had any field experience in her general pedagogical classes (as an undergraduate in the 1970s) before she began student teaching. Don also reported that he had a little teaching experience in his general pedagogical courses.

Don and Kathy had different views about their teaching experience in these science methods courses. For Don this experience was "actual teaching" more than observing others teaching. For Kathy, the methods III course experience was not so good because the teacher she was assigned to, was not a good model teacher. For her, the Methods III course did not, "seem like it was a period of real growth." Yet, in this course students are supposed to accumulate 75 hours of teaching experience.

The internship in teacher education at NGU was one year long. During this year prospective science teachers were assigned to a school for nearly full-time teaching. Throughout the internship, prospective science teachers stay in one placement working under the supervision of collaborating teachers and university staff. The internship was both part of separate courses to address management issues and integrated into existing courses to continue development of effective models and techniques of teaching.

For example, the structure of the TE 802 course was feedback from interns and in-class discussions, meeting interns with field instructors, demonstrations and discussions, topic/activity of the day (this was conducted in small groups), and needs assessment, (TE 802 Syllabus, Fall 1994). The instructors of TE 802 and TE 804 organized their courses around collections of issues (e.g., classroom management, portfolio, unit planning, and assessment) that prospective secondary science teachers would face during the internship year.

Student teaching in the teacher education program at SGU was 16 weeks long. Prospective secondary science teachers were assigned to teach in middle and high school for one semester. It was part of a course that consists of 30 hours seminar and 16 weeks of student teaching. Prospective secondary science teachers were required to have teaching experience in different grade levels through their science methods courses: elementary, ninth, and middle school/junior high. The elementary teaching experience was most frequently in kindergarten. During their student teaching, prospective secondary science teachers were able to reflect on their own teaching on the seminar part of this course.

Even though it is a program requirement to teach for one semester or one year, it turned out that each one of the four teachers had different experiences. Terry and Steve valued their student teaching experience because they had a chance to talk to and work closely with "another science teacher." Having a professional secondary science teacher(s) within the course instructors team could help narrow down the course objectives and course instructional strategies to be closer to the real classroom setting. For example, interns and instructors would discus issues, ideas, and share information that sounded valuable to interns to know and practice. This kind of interactions could be a useful strategy that might help interns construct their pedagogical content knowledge.

Another factor that shape their teaching experience is the school context. For example, Steve did his student teaching in an innovative high school where the field instructor was his collaborative teacher, too. She watched his teaching, "maybe six times," and gave him direct and written feedback, "right after the class." The science department at the high school has a long history of deep involvement in NGU's teacher education program and Steve's collaborating teacher is perhaps the most involved of the teachers. Furthermore, she has won several awards for her outstanding teaching.

At this school, Steve felt that the, "staff and faculty at [school name] was real helpful." So, Steve felt that he was a "contributing member." This feeling, especially during student teaching, is essential to help prospective teachers to gain self-confidence. Also, it would ease and open communications between interns and inservice teachers.

For Kathy student teaching, "was a real good experience." But in the school in which she did her student teaching there were a lot of, "discipline problems," because the school principal was new and he had a lot of personal problems and he was not there, "even half of the time by the end of the semester." Kathy mentioned that some teachers tried to keep the discipline under control. It is clear that doing student teaching within such a school context could minimize the benefit from this experience. However, Kathy reported that regular classroom activities "were really no problem," but any out of school activities such as field trips were difficult to organize.

Another factor that could influence teachers' knowledge, beliefs, and performance is a teacher's characteristics. Don, who experienced almost the same science education programs as Kathy at the same time in SGU, ended up by having an "excellent" field experience for the science education part. It appears that there is something more important than program influences to his teaching and performance. It is self-attributes that Don has. For example, Don is a self-motivated person. Whenever, Don was asked to observe teaching or visit schools he was asking to teach, and he did that in any field experience that he had. He said, "the first day I ever went into any of the experiences... [I] asked that I'd like to have some teaching experience whether I screw up or not." He taught in all of his field experiences. Furthermore, he taught at "every level," kindergarten, junior high, and high school.

Don was an "initiative person." In the high school to which he was assigned, the cooperating teacher's son had a heart attack and died. He took initiative when this happened and took over her class. He says:

> "...when I went to the high school and junior high, I taught them and we took an organized big field trip and took all the seventh and eighth grades out to the [River name]. High school, um, student teaching, *I did some extra stuff out there and got to teach them kind of my own initiative about the student teaching*, I got to, *I started out teaching several classes* and in my situation, when my cooperative teacher's son had that heart attack and died, she left and I just took over her class. They had a substitute come in but I just had it worked out with the school that I just take over her class until she came back...*I ended up having a pretty good teaching experience* for me because I was kind of thrown into being a full-time teacher even though I was still in school. *But that was really a unique experience* so I felt like I'd had a, I'd been kind of tested on the battle ground for my first review" (NTI, 1996). [emphasis added]

It is clear that Don took the first step to substitute for that teacher because he realized that being involved in teaching is one of the most important tools to grasp the craft of teaching (Holmes Group, 1990; American Association for the Advancement of Science, 1998).

Also, Don mentioned in his videotaped lessons that he went to an X-ray center to get some X-ray films to share the real world applications of magnetic spectrum with his students. Don reported that he had a thoughtful conversation with the radiologist physician about how to interpret these X-rays films and how to make use of that professional knowledge in his teaching. This kind of action indicated that Don is a curious person who is willing to ask and learn from different resources, especially, professional people.

It is common that new secondary science teachers, especially in their first or second year of teaching, are not ready to have this level of communication with professional people in different disciplines. However, Don makes his teaching more realistic and to some extent makes his students' learning connected with the real world applications by contacting professionals. These kinds of applications that Don made in his teaching between content knowledge and outside school applications (i.e., real world applications) could be interpreted as teaching for external applications (Cajas, 1998), which be good because students are able to use school science in their out-of-school experiences.

In the students' actions domain, the study found that the beliefs of the four teachers' were more consistent with their actions than in any other domain. Terry, Kathy, and Don expressed student-centered knowledge and beliefs, and displayed student-centered teaching performance, too. However, Terry and Kathy displayed some aspects of teacher-centered teaching. Steve displayed conceptual teaching, while, he expressed conceptual and student-centered teaching beliefs.

The study found that there is a relationship between these outcomes and some of their experiences when they were prospective teachers in the science methods courses. Prospective secondary science teachers were asked, "How often were cooperative learning techniques used in your teacher education courses?" According to their responses to this question, all of them reported that they mostly experienced "cooperative learning" in their teacher education courses, especially in the methods courses. Steve had this experience, "seventy five percent of the time," Terry had this experience,

> "More often in my methods classes than my general classes. Every methods class had at least part of the time in groups to model group work. *We also discussed ways to use groups in the classroom"* (NTI, 1996). [emphasis added]

Kathy's experience in cooperative learning was in methods courses that she took at SGU. During her methods II course, she worked with two other students in designing and teaching a unit (e.g., food and nutrition) for a few days out in schools. She referred to this experience as teaching in an, "artificial setting." The nature of her group work that she was in was not always positive because, "the other two student teachers and I weren't always in agreement over what we should do." However, Don, who graduated from the same program, used the term "family" to describe his cooperative learning experience in his methods courses. Within this program there were about 15 prospective secondary science teachers who went through a two year program. So, according to Don, within this group of prospective teachers,

> "..there was a lot of cooperative learning there just by the fact that *we were with each other for so long that we got comfortable sharing things with each other* and whether that was the objectives of the program or not, that's something that's like cooperative learning that kind of came out on it's own maybe rather than going to class and having them actually doing a cooperative learning activity. *But the way the program is set up, I think cooperative learning is just natural"* (NTI, 1996). [emphasis added]

So this experience helped Don to share with other prospective secondary science teachers ideas, articles, and other resources helpful to teach specific science topics. This kind of interaction within groups could help them to acquire what Grossman, (1990); and Magnusson, et. al (1994) called topic specific teaching strategies.

However, the experience of cooperative learning that the four prospective secondary science teachers practiced in their teacher education programs did influence their knowledge and beliefs about their student' actions more than their teaching performance.

One reason, could be that the instructors of teacher education programs structured activities for their students to work in small groups, but they may not have demonstrated good models of "cooperative learning techniques." So, the prospective teachers went out from these classes with ideas of using cooperative learning and small groups in their own teaching without acquiring the skills that allowed them to use this teaching strategy effectively to promote students' understanding. This argument fits with what the director of education center at SGU believes about the nature of cooperative learning in the science education seminars, "may be it is not exactly cooperative learning."

Limitations of The Study That Influenced Findings

- Pedagogical content knowledge (PCK) is an essential component in any teacher education program that structured to prepare prospective teachers to teach for understanding. However, this study was not able to find any significant outcomes which related to PCK for each new secondary science teacher. The two major instruments that were used in this study: TPPI and STAM-Science Version were not able to support the study with enough data to draw any conclusion about their PCK. To report finding about PCK, either these instruments need to be modified according to one of the PCK models that are well known in teacher education (for, example, Grossman, 1990; or Magnusson, et. al, 1994), or new instruments need to be developed to be used in conjunction with STAM, TPPI and the other interview protocols.

- The using of supercodes to describe teacher's knowledge and beliefs was problematic in coding teachers' beliefs. For example, in the environment domain there is only one question in the TPPI interview used to code teacher's knowledge and beliefs into two categories teacher-centered or student-centered. This question was, " What are some of the thing you believe your students value most about their educational experience in your classroom?" The same problem exists in the diversity domain where there was only one question that coded into three categories; didactic; transitional; or conceptual to describe teacher's knowledge and beliefs. The prospective secondary science teachers where asked, "How do you accommodate students with special needs in your classroom?" In the context domain there were three questions were coded into two categories teacher-centered or student-centered. A related problem with the supercodes was responses that were did not fit the conceptual frameworks of teacher-centered, conceptual, or student-centered teaching were force fitted into those categories. For example, teachers who identified time as a constraint were coded as didactic teachers in the supercodes. This is a gross oversimplification introduced into the process of data analysis.
- Using the video portfolio to describe teaching performance limited the researcher ability to analyze teacher's teaching performance. In the videotaped lessons the focus was mostly on teacher. So, in the classes where students work in groups it was difficult to hear much from student-student interactions or the interaction between teacher and students while they were working in groups. So, to overcome this

problem for future research, I recommend either direct classroom observations or careful attention to videotape quality which may necessitate providing better equipment to teachers for recording their classes.

- This study found that Steve and Terry taught in the areas in which they lack a strong background, which differed the other two cases who related areas of strength for videotaping. However, none of the four new secondary science teachers taught from their majors (i.e., biology) in their videotaped classes.
- Terry taught in a very difficult school context where virtually all of her students were classified as at risk and many were also classified as special education students. She taught in an urban setting and had no classroom of her own. As a result whatever materials she used in teaching had to be hauled from room to room on a cart. The teaching context for Terry was very different from that of the other three new teachers. As a result comparisons among the four new teachers have diminished efficacy.
- Information about Steve's background was not accessible because he is Japan teaching English as a second language. So, no current e-mail interview was done with him.
- Data from CLES was not available for all teachers and their students. This diminished the utility of this data source.
- SGU and NGU graduates were at different experience levels because of the way experience was counted. SGU graduates had a semester of supervised student teaching plus a full year of paid contract work prior to the year studied. NGU

graduates had their internship year behind them prior to the year studied. NGU graduates were in their first contract year during the period studied.

CHAPTER 6

REVIEW OF THE STUDY, DISCUSSION OF THE RESEARCH QUESTIONS, IMPLICATIONS OF THE FINDINGS, AND RECOMMENDATIONS FOR FURTHER RESEARCH

Review of The Study

The purpose of this study was to investigate the influence of teachers' characteristics and secondary science teacher preparation programs on new high school chemistry teachers' knowledge, beliefs, and performance. Reviewing the literature indicated that little research has been done to explore the influences of teachers' characteristics and science teacher preparation programs on their knowledge, beliefs, and teaching performance. Salish was the only study that addressed these issues on a national level, but it was an exploratory study that was broadly focused on the relationships among students' outcomes, teachers' knowledge and beliefs, teachers' performance, and teacher education program features. Another study that was done in conjunction with Salish (Tillotson, 1997) explored the connection between the important features of the Iowa-UPSTEP program and performance characteristics of new teachers (NTs). These NTs were graduates of the program in the early stages of their teaching career (first 1-3 years).

However, my study is the only study that aimed to explore in-depth the connections among four domains: teachers' characteristics; science teacher preparation programs; teacher's knowledge and beliefs, and teachers' performance. To explore these connections, a cross-case analysis was done between the high school chemistry teachers who graduated from the two teacher preparation programs. Further cross-case analysis was done among the four cases to compare the two different programs.

The findings presented in chapters three, four, and five suggest that the teacher preparation programs in the two institutions have a number of key features which were found to be linked to different teaching styles (i.e., teacher centered, conceptual, and student-centered) that was displayed through the new high school chemistry teachers' performance or expressed in their knowledge and beliefs. These findings are:

- The course objectives in the teacher education programs at both institutions were diverse and more comprehensive than science disciplinary program course objectives.
- All four of the teachers and most of the faculty interviewed confirmed that the connections between prospective science teachers' learning and real world applications were not clearly addressed as a major goal in science courses at either institution.
- Prospective science teachers did not experience cooperative learning in their science classes.
- All new secondary science teachers reported that they used a variety of assessment methods in their science education courses.
- All four of the teachers identified that learning from on-the-job experience or field experience in their teacher preparation programs was a crucial factor in developing their teaching models. The year long internship in the teacher education program at NGU was valued by Steve and Terry.

- While all four of the secondary science teachers hold student-centered beliefs about teaching, only one effectively demonstrated student-centered teaching.
- The new secondary science teachers did not reflect a deep conceptual understanding of the scientific concepts that they taught in their video portfolios.

Also, the study found that there was a relationship among these teachers' characteristics and their knowledge, beliefs, and teaching performance. These findings add an important contribution to the existing research base in science teacher education because it highlighted the features of science teacher preparation programs that contributed to different teaching styles.

In this chapter, the implications for several groups of individuals will be discussed. Specifically, implications for teacher education programs, science teachers, professional education faculty, and school administrators were made. The implications are drawn from the most significant findings which represent a limited group of those that were presented through chapters three, four, and five. The opportunity for making generalizations does not exist (Lincoln & Guba, 1985; Stake, 1995; Yin, 1984) because the case study design does not represent a sample from which we can generalize into populations. The implications of the findings from this study may very well transcend the two teacher preparation programs that were studied. The findings should be evaluated by faculty and administrators to determine their applicability to their local institutional setting.

Discussion of The Research Questions

This study sought to investigate the following research questions:

1) What is the training of new high school chemistry teachers? In order to answer this question, the following sub questions need to be answered:

   a) What is the variety of subject matter background they experience during their pre-service education?

   b) What kind of courses did they take?

   c) What kind of chemistry training and experience did they have?

   d) What is their background in mathematics and physics?

   e) What is their pedagogical training in teacher education?

2) What are the features of the teacher preparation programs these teachers experienced?

3) What are their beliefs about the nature of science and teaching science?

4) What are the key features of the classroom performance of these new high school chemistry teachers?

5) What kind of preparation experience and knowledge contributes to a teacher-centered, conceptual, or a student-centered teacher?

All science teacher preparation programs are intended to prepare new high school chemistry teachers, as well as science teachers more generally, to be effective teachers in the classroom. The reality is that this fails to occur in many cases. The reason for that failure has been attributed to a number of factors within programs that are not adequate to make changes in the minds of prospective teachers (Hewson, et. al, 1992) and to the socializing influences operating within school cultures (Zeichner & Gore, 1990; Zeichner & Tabchnick, 1981; Anderson & Smith, 1987).

In the case of Terry and Steve, the NGU program influenced their teaching performance, knowledge, and beliefs differently. The same is true of the two cases from SGU (Don and Kathy). Terry, Steve, Don, and Kathy shared some similarities in how the important factors of their teacher preparation programs shaped their teaching philosophy and behaviors. Terry faced conditions in her school environment which influenced her teaching in ways more pronounced than the other teachers.

Question 1: What is the training of new high school chemistry teachers?

This study found that the four NTs had biology as a major and chemistry as a minor. Don had physics as a second minor. The training in chemistry for these four teachers[1] was through general chemistry courses and labs, organic chemistry (I & II) and their labs. Kathy also took courses in qualitative analysis and lab, and biochemistry and lab. Terry took two courses inorganic chemistry with labs, and one course physical chemistry. Don through his teacher education program took two courses in applied physics, and applied biology, and general astronomy.

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[1] As I mentioned before, data about Steve's background was not accessible because he is in Japan teaching English as a second language. He was with Terry in many of the same teacher education classes, and it is quite likely the shared many of their science content courses (they have the same major and minor and both graduated from NGU in the same year).

While the four teachers were biology majors, none of these teachers submitted video portfolios of biology teaching. Steve is the only one who taught chemistry in his three videotaped lessons. However he admitted that his background in chemistry was not strong. Also, Terry taught a physics topic while she admitted that her background in physics was not strong. As an undergraduate, she took one year of introductory physics with lab.

Among the four cases, Don, who taught electromagnetic spectrum to his students took 8 semester hours in physics plus he took the applied physics course that was offered through science teacher education program at SGU.

The nature of the science courses that they experienced in their science component of their programs was content-oriented. Teaching in these courses reflected an "anti-model" of constructivist teaching. Generally speaking, science faculty in the two programs used lecture as a common teaching strategy in their teaching. Moreover, they were perceived by these NTs at teaching science concepts in a superficial way, without focusing on representation of the complex relationships that connect concepts together. Moreover, the concepts generally were not applied to the "real world" of students' experience. Connections between prospective secondary teachers' learning in the science disciplinary content courses and real world applications were not strongly addressed as a major goal of teaching science in either of the institutions. This lack of connection helps entrench these prospective teachers' beliefs about the isolation between teaching or learning science and students' lives.

Furthermore, the separation between the lab and the lecture influenced these teachers' perceptions about the nature of the lab. They perceived the science lab as a vehicle to confirm scientific facts, laws, and theories, not as a teaching strategy that would help them to construct their understanding (i.e., lab was not seen as an inquiry-oriented) (Erwin & Pestel, 1992; Vieira & Oliveira, 1997).

Question 2: What are the features of the teacher preparation programs these teachers experienced?

The outcomes of the programs' analysis showed that the new secondary science teachers experienced more diverse and comprehensive course objectives in their teacher education courses than in science disciplinary program courses. The common goal of science methods courses at SGU was to provide prospective science teachers with knowledge based on educational research. Using research-based knowledge in teaching science method courses would reduce the gap between theory and practice. At NGU, the common goals for the science education courses were to teach science for all students and to teach that teaching is a profession. Teaching science for all students is a requirement to promote scientific literacy (AAAS, Science for All Americans, 1990). Furthermore, to teach all students successfully, teachers need to be aware of students' unique needs related to their learning.

All four of the prospective science teachers reported that they used a variety of assessment methods in their science education classes. For example, the most common assessment methods that they experienced in their science education courses were papers, interviews, presentations, project, and student teaching. However, NGU graduates used to write journals more often in their science education courses in addition to the methods employed at SGU. Using different methods to assess students' understanding is one of the most common outcomes in science education research that would help focus on students' misconceptions and students' learning.

A very important feature in the teacher education program at NGU is the one year internship program. Through this program prospective teachers practice their own teaching for a year under supervision of field instructors and collaborating teachers. At SGU prospective teacher had the chance to experience teaching for only one semester. In addition to that, the four science teachers had some teaching experience in their science method courses prior to student teaching or the internship.

The reform agenda in science education asked to increase prospective science teachers' practice in schools (AAAS: Blueprints for reform, 1998), in order to help them gain first hand experience in teaching science. This teaching experience through their internship would help prospective teachers to integrate between content of science and students' learning (Anderson, et. al, 1998). However, some factors would minimize the benefit from this teaching experience like school context, collaborating teachers, teaching loads, teaching out of their majors, and students' attitudes toward learning science.

In both institutions, the coherence between science disciplinary departments and teacher education programs seemed weak. It was described by faculty members and prospective teachers as informal and not strong.

However, at NGU there is growing communication between faculty from both sides. Recent initiatives have strengthened this considerably since Steve and Terry graduated. There are structures in place to facilitate communication and collaboration between the faculties of the College of Education and the College of Arts and Science. There has been a major grant recently awarded that stems in part from this improved communication between the two colleges.

It was clear that prospective science teachers experienced a wider variety of instructional strategies in teacher education courses, specially in science methods courses when contrasted with science courses. They experienced small group discussion, teaching, group projects, group work, and cooperative learning. In science courses lecture was the dominant teaching method.

Question 3: What are their beliefs about the nature of science and teaching science?

In general, the study found that all of the new high school chemistry teachers hold student-centered teaching beliefs as dominant, but they also hold some aspects of conceptual and teacher-centered beliefs. This provides evidence that these prospective teachers had consistent knowledge and beliefs about their teaching. However, their knowledge and beliefs about how they perceive their science content were shifted away from student-centered teaching beliefs. For example, in their knowledge and beliefs about how they view science content, Steve, Terry, and Kathy reflect that they see science as two separate entities: content and process (AAAS, 1990; American Chemical Society, 1990; Kirk & Layman, 1996). Their image of science may have been acquired from the long experiences of learning science K-20 (Ben-Peretz, 1995; Lortie, 1975).

On the other hand, the new high school chemistry teachers in the other domains (e.g., students' actions) mostly expressed student-centered teaching beliefs. For example, they believe that students can learn in different ways, and they acknowledge that learners are diverse. They recognized that there were students with special needs in their classes. They expressed different ways of dealing with those students' needs.

Question 4: What are the key features of the classroom performance of these new high school chemistry teachers?

The outcomes of the video portfolio analysis for Terry, Steve, and Kathy suggest that they have not have achieved a degree of success in implementing student-centered teaching practices. They displayed teacher-centered teaching performance. However, Don achieved a degree of conceptual and student-centered teaching practices. Steve sometimes displayed a conceptual teaching style. Terry was plagued by students' disruptions and off-task behaviors while attempting to teach in a student-centered manner.

This discrepancy in these prospective teachers teaching practices could be influence by school contextual factors. For example, Terry taught in a school where most of her students could be considered as students with special needs. She taught in an urban setting in classes consisting almost entirely of at-risk students. However, Terry in her first year of teaching (in the internship year) displayed conceptual and student-centered teaching style. While she secured a job in the same school as where she completed her internship, the nature of the classes she taught in the two years was quite different. In here internship year, she taught primarily biology to students in the college track. In her first year as a professional, her student population was almost entirely non-college bound. After completing her first year as a professional in this setting, she moved to a suburban district well known for its innovative teaching practices and she is thriving in the new environment.

Kathy taught in school that lacks resources. For example, she could not find enough textbooks for students to do their homework. She did not even have an overhead projector to present some transparencies in her biology class.

Other factors could contribute to the teachers' performance is teachers' subject matter background which is essential for the purpose of teaching (Hashweh, 1985; Latz & Lederman, 1996; Wilson, et. al, 1987). Terry and Steve reported that they chose to teach topics in their videotaped lessons that they have difficulty with in order to get feedback from Salish staff to improve their teaching in these areas.

Another factor that might influence science teachers' teaching is the amount of content that they are supposed to cover during the school year. TIMSS (1997) study indicated that in The United States science teachers in the 8th grade covered many concepts within one year (about 60), while in the other countries like Japan teachers covered about 5 big ideas during the school year. In summary, TIMSS study as well as National Research Council (i.e., National Science Education Standards) (1996) recommended that science teachers cover less science content in order to teach it in depth. Furthermore, many scholars recommended that more emphasis must be placed on science as a method, not a collection of facts, and on the processes of investigation (Lloyed, 1994; Lloyed & Spencer, 1994; Rickard, 1992; Spencer, 1994)

Question 5: What kind of preparation experience and knowledge contributes to a teacher-centered, conceptual, or a student-centered teacher?

The study found that there were key features of the teacher preparation programs or teachers' characteristics that contribute to teacher-centered, conceptual, and student-centered teaching styles. In general, the findings indicate that new high school chemistry teachers have inconsistency between their knowledge, and beliefs, and their teaching practice. Terry, Kathy, and Steve mostly hold student-centered teaching beliefs, while they demonstrated an array of teaching styles that tended toward teacher-centered style. However Steve sometimes displayed conceptual teaching. Don was the only one who displayed and expressed student-centered teaching knowledge, beliefs, and performance.

All four of the teachers were taught science as undergraduates in large classes (i.e., 800 students) with science majors. However, Steve and Terry attended one science laboratory course for secondary science teacher candidates. In science classes, prospective teachers were passive most of the time. The teaching environment in these classes was teacher-centered. Instructors focused on delivering content to their students. The connection between science content and science process was not strong. Real world applications in prospective teachers' learning were not often implemented in their college science classes. The lab only occasionally connected to the lecture.

This way of learning science influenced new high school chemistry teachers' knowledge, beliefs, and performance. Terry, Steve, and Kathy view science as two separate components. Also, in their teaching they focused over the factual and descriptive nature of scientific knowledge. However, Steve sometimes displayed some conceptual teaching in his teaching. Don had some extra background in physics. He took an applied physics class and an astronomy class, In these two classes Don had the opportunity to experience the connection between science process and content to a grater extent than was the case in other science courses. In general his experience in science classes was almost the same as that of the other three cases.

All four of the teachers most commonly experienced small group and cooperative learning in their science education courses. This experience influenced their teaching knowledge and beliefs in terms of their students' actions inside the classroom. All of them in their videotaped lesson used small groups in their teaching, but they did not always use it effectively. One interpretation of that is that as prospective teachers they were not taught how to use these techniques to teach for students' understanding. In other words, the science education faculty might not model cooperative learning effectively in their teaching, so, how can we expect that from prospective teachers? Other possibility might be related to the time concerns, because using this method of teaching needs more time and science teachers usually concerned about covering much content (NCR, 1996; Rodriguez, 1998; TIMMS, 1997). Rodriguez (1998) confirmed that high school science teachers face everyday the dilemma of managing the demands of a, "content-laden curriculum."

Another factor that seems to be crucial to prepare prospective science teachers was the teaching experience that they had through their science education program. Don believes that that experience contributed to his teaching model at an about 80%level, whereas the other three NTs see it matching a smaller contributions. Whenever, he was assigned to a field placement Don would ask to practice actual teaching and not to simply observe teaching. Learning from experience was common among these four teachers. However, Steve reported that it is important to have experience in education as well as learning from experience. He used the metaphor, "Riding a tricycle before you ride a bicycle." This metaphor of a prospective teacher's view indicates that the teacher education courses are essential for prospective teachers to cultivate more from their teaching practice to become professional science teachers.

On a quite different not, Don and Kathy did not show enough evidence that the courses they took in the history and philosophy of science had an effect on their teaching practice or in their knowledge and beliefs.

Implications of The Findings

The focus of this study was on the teacher preparation programs in two institutions: NGU & SGU, its faculty, and new high school chemistry teachers who were graduates from these programs. The case study design prohibits making sweeping statements of implications for all science teacher preparation programs (Stake, 1995; Yin, 1984). This design would help researchers to generalize findings of the study to some broader theories in the field of teacher preparation programs. The findings in chapters three, four, and five were based on the researcher's analysis of each participant's data, and those chapters attempted to describe their perspectives with respect to the research questions. This must be taken into account when considering the implications of this study.

One of the major implications drawn from this study is that the orientation of science content classes needs to be changed in order to fulfill the needs of prospective science teachers. Steve suggests in his TPPI interview that we should, "reassess undergraduate college," because science teaching in college is, "so geared towards the pre-med type." So, it is essential to restructure some science courses to focus more on content knowledge for the purpose of teaching. To acquire this, science teachers need to learn science in a classroom setting that encourages them to construct their understanding. The matching between the lab and lecture is a helpful tool that integrates between science content and science process. Also, making real world application could help break down the abstract level of science concepts.

Another key implication which emerged from this study is that the faculty in teacher education courses need to model constructivist teaching and give their students essentail experience in practicing it . So, you cannot effectively teach constructivist learning by lecturing about it. Shymansky (1992) asked that all facets of preservice education programs should model constructivist teaching if we want new secondary science teachers to implement that in their teaching. My study has shown the inconsistency between new teachers' beliefs and performance when they used constructivist approaches in their teaching. For example, Steve wanted to experience more hands-on instruction in all his college courses. He says:

> "Well, it's kind of like you get *in the education classes and they tell you how much of hands-on learning* and then, you know,, *then conceptualizing is so good and then I think: If it's college professors teaching this why are no college courses like that*, or very rarely, you have college courses like that? So,...it would be great if they could do that, *if there were more hands-on type instruction*...they say, chemistry lab...you follow the recipe....You mix what was supposed to be mixed and you know, *I don't know if that's any different than sitting in a lecture hall"* (NTI, 1996). [emphasis added]

One important implication of this research is that learning from experience was crucial learning tool addressed by all four teachers in this study. So, having teacher education program with one full year of student teaching is a key feature in the program that allow prospective teachers to test their own theories about teaching. All four of the new teachers agreed on the need to expand the practice teaching time, especially in the methods courses. This would provide great support for new teachers as they learn to use more effective approaches to teaching. However, the level of accomplishment from this experience is influenced by several factors; collaborating teachers, administrators; school context; prospective teaches' personal characteristics; and students' behaviors. So, in placing prospective science teachers in school these factors should be taken in account.

Finally, increasing the communication and collaboration between science disciplinary departments and teacher education is important. One way is through small group discussion that might lead to design courses that better combine content and pedagogy, such as applied science courses for prospective teachers and collaborative research projects to serve teachers' needs. Don's background who enhanced as a result of applied science courses, and he exhibited more student-centered teaching styles.

Recommendation for Further Research

This study identified several important linkages among teacher preparation program features in the two institutions (NGU & SGU), teachers' characteristics, teachers' knowledge and beliefs, and teachers' performance. But still there are several areas which are in need for further investigation. The following list of recommendations for further studies related to the preparation of prospective secondary science teachers:

- Giving the fact that this study focused on new high school chemistry teachers, further research is needed to cover other science disciplines like physics and biology.
- The four teachers in this study had biology majors and chemistry or physics as a minor and only one of them taught chemistry topic for their video portfolios. Therefore, further research is needed to follow teachers who are teaching topics in their major field of study to see the influences of content background on their teaching performance.
- Further research is needed to explore the influences of teacher preparation program feature on prospective science teachers' performance in more than one year of teaching. This kind of research would widen science teacher educators and scientist' understanding about the changes in these teachers practice according to interaction between their graduate/undergraduate training and their teaching experience.

- Given the fact that this study focused on two teacher preparation programs, further research is needed to cover some of the other seven institutions who were part of Salish study.

APPENDIX A

PERSONAL BACKGROUND

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PERSONAL BACKGROUND

In this study I focused on new high school chemistry teachers because my academic and professional experiences in chemistry allow me to do that. I had a bachelor's degree in chemistry (B. Sc.) from Yarmouk University in Jordan. This four year program in the college of natural science helped provide me with knowledge and laboratory skills in chemistry as well as in other science disciplines, mathematics, physics, and statistics. In chemistry, I took courses in general chemistry, organic chemistry, inorganic chemistry, analytical chemistry, physical chemistry, instrumental analysis, qualitative analysis, forensic chemistry, and techniques of separation.

Beside chemistry courses, I took courses in mathematics: calculus I & II, intermediate analysis, and ordinary differential equations. In physics, I took general physics I & II with labs, and electricity & magnetism. With this academic background in chemistry and other science disciplines, I felt more confident to analyze the new teachers knowledge and beliefs, and their performance in chemistry than in other science disciplines.

Having a Master of Arts degree in science education from the University of Jordan improved my ability to integrate between my background in chemistry (content) and pedagogy through science methods and general pedagogical courses that I had experienced in the Master's program. At the Ph.D. level I gained more academic and professional experiences in science education through the course work that I have done.

My working in Salish I Project from 1994 until the project completion in 1997, helped me to gain a first hand experience in conducting research, collecting, coding, analyzing, interpreting, and reporting data. In addition to my research experience, I taught chemistry for high school students (grade 9 - grade 12) for 10 years in Jordan. I was working in the Model School that connects to the College of Educational Sciences in The University of Jordan. Moreover, I was teaching in The Department of Curriculum & Instruction in the University of Jordan as a full-time Lecturer. I taught science methods courses for science majors who were prospective science teachers.

In the United States, I was science graduate assistant for TE 402 science methods course at Michigan State University. As a chemistry lab coordinator for three years to the two introductory chemistry lab courses in a residential science department in the college of Natural Science at Michigan State University, I taught these two courses, also I supervised the undergraduate chemistry teaching assistants. In addition to that, I supervised operations related with these two labs.

Through The Salish Project, plus the academic and professional backgrounds that I have, I was able to construct my own framework for my dissertation.

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