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Teaching and Learning: Novie Teachers' Descriptions of their Confidence to Teach Science Content

Barbara Ann Ford

ACCEPTANCE

This dissertation, TEACHING AND LEARNING: NOVICE TEACHERS' DESCRIPTIONS OF THEIR CONFIDENCE TO TEACH SCIENCE CONTENT, by BARBARA ANN FORD, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University.

The Dissertation Advisory Committee and the student's Department Chair, as representatives of the faculty, certify that this dissertation has met all the standards of excellence and scholarship as determined by the faculty. The Dean of the College of Education concurs.

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ABSTRACT

TEACHING AND LEARNING: NOVICE TEACHERS' DESCRIPTIONS OF THEIR CONFIDENCE TO TEACH SCIENCE CONTENT

by

Barbara Ann Ford

STATEMENT OF THE PROBLEM

The problem being studied in this research is the relationship between a specific series of integrated science courses in a science teacher preparation program and the actual needs of the science teacher during the first years of teaching practice. Teachers often report that there is a disconnect between the coursework they have taken in college as pre-service teachers and the reality of their classroom practice during their first years of teaching. The intent of this study was to record the descriptions of three teachers who were members of a cohort and took a series of integrated science courses (NSCI series) during their teacher preparation program as it related to the influence of these courses on their teaching practice. The focus of inquiry is guided by a single question: How do former participants in the series of science courses who are currently novice teachers describe their confidence in their ability to teach science content to their middle school students?

The theoretical framework was based on Shulman's (1987) pedagogical content knowledge (PCK). PCK involves the teacher understanding the content of science so thoroughly that ways are identified of representing and formulating the subject matter to make it understandable to others. The teacher who has a strong PCK uses powerful analogies, illustrations, examples, explanations and demonstrations that promote personally meaningful student understandings. Novice teachers' reflections on their confidence to teach science content to their middle school students were observed through the lens of PCK.

All three novice teachers reported a high confidence level to teach middle school science and attributed their confidence level to a great degree to the integrated science series of courses (NSCI).

METHOD

A qualitative design, specifically a case study, was used for this study. Multiple forms of data collection were employed including a semi structured interview and a focus group. Data was collected, categorized and analyzed over a six week period. A constant comparative method (Bogdan & Biklen, 1998) was used to examine the data. Triangulation, member checking and a peer reviewer were used to reduce the risk of bias and increase the trustworthiness of the data.

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Barbara Ann Ford

A Dissertation

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During the time I was finishing my degree, two of the most beautiful babies in the world were born: Maggie and McKinley. It was so tempting to play with the girls instead of working on this manuscript and sometimes I gave in to the temptation.

Finally, to my husband, Larry, who supports me in everything I do, thank you for your patience with me and loving me when I am least loveable.

Jeremiah 29:11. God has a plan for me. It has been a long journey for Larry and me from children of poverty from the slums of Sawyerwood to Georgia State University Ph.D. I praise Him for the path and for His presence.

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ABBREVIATIONS

AAAS	American Association for the Advancement of Science
NI	Needs Improvement
NOS	Nature of Science
NSCI	Natural Science prefix for courses
NSTA	National Science Teachers Association
PCK	Pedagogical Content Knowledge

CHAPTER 1

STATEMENT OF THE PROBLEM

The problem being studied in this research is the relationship between a specific series of integrated science courses in a science teacher preparation program and the actual needs of the science teacher during the first years of teaching practice. Teachers often report that there is a disconnect between the coursework they have taken in college as pre-service teachers and the reality of their classroom practice during their first year of teaching (Craven & Penick, 2001). The intent of this study was to record the thinking of three novice teachers who were members of a cohort who took a series of integrated science courses (NSCI science sequence) during their teacher preparation program. The goal was to allow the participants in the study to describe their confidence in their ability to teach science content. The focus was specifically on the role the previously completed NSCI series played in their current description of their confidence.

This study was guided by a single question: How do former NSCI participants who are currently novice teachers describe their confidence in their ability to teach science content to their middle school students? The ultimate goal of this information was to discover if this series of courses promoted confidence in the participants' ability to teach science content.

Teaching is a complex and daunting task for which teachers must be well prepared to be successful. Science teaching in the middle grades is even more complicated because by the time students have arrived at the doors of the middle school,

they have often had uneven preparation for the curriculum because of the inability of elementary science teachers either to teach science content or to spend an adequate amount of time teaching science (Lilly & Sirochman, 2000). Science has been an area of the educational program that has been under fire for not producing high student achievement. Science teaching and, therefore, science teacher preparation programs have been criticized for not preparing students for the 21st century issues and dilemmas (Schmidt, McKnight, & Raizen, 1997; National Research Council [NRC], 1996).

According to the National Commission on Mathematics and Science Teaching for the 21st Century (2000), “the most powerful instrument for change, and therefore the place to begin, lies at the very core of education – with teaching itself” (p. 5). No matter what curriculum, program, or new initiative that is implemented in the classroom, it is the work of the highly skilled, confident teacher who makes the difference in the learning of the student (Darling-Hammond, 1998, 2000; Marzano, 1992). Teachers who understand their content in a way that allows them to transform it so that students are also able to understand it are to able motivate and inspire students to higher levels of learning (Danielson, 1996; McDonnough, McKelvey, Baski, & Lewis, 2004; Sparks & Hirsch, 1997). They are able to transform that content into metaphors and analogies, and they can teach in ways that allow students to understand the big picture as well as the smallest details. They are confident in their abilities to teach and try more strategies with their students, are more enthusiastic about the subject matter, use multiple resources, are able to identify preconceptions and misconceptions and address those needs with their students and are able to persist longer without giving up on the students (Llewellyn, 2002; Patrick, Hisley, Kemplers, & College, 2000).

Those who are not as confident resort to more traditional methods of teaching: read the book, answer questions, and write the glossary words in their dictionary. Their modus operandi seem to be to resort to more transmission methods with low-level and factual questioning (Carlsen, 1987; Duggan-Haas, Enfield, &Ashmann, 2001; Grossman, 1985; Keble & Howard, 1994).

An overarching principle of the Commission's vision for change was to improve teacher preparation programs in the area of science and math so that teachers have a strong understanding of science content, skills to motivate students to learn, and a repertoire of effective and successful teaching methods that result in confident practice (Rice & Roychoudhury, 2003). Science teacher preparation programs where thinking, reflection, and examination of beliefs are encouraged should produce science teachers that have improved attitudes, habits of mind, and understandings for teaching toward scientific literacy (Craven & Penick, 2001).

Models such as Project 2061 (American Association for the Advancement of Science [AAAS], 1989) and the National Science Education Standards (NRC, 1996) describe how science teachers could teach science in engaging, inquiring ways that allows students to construct meaningful knowledge. Driver (1989) refers to teaching in ways that are meaningful to the student as constructivism. Constructivism is a way of knowing (epistemology), an ontology (the only truth is what is personally mediated), and a way of doing (referent) in the science classroom (Dewey, 1916; Gredler, 2001; Piaget, 1977). Constructivism allows students to use their personal experiences and prior knowledge to interpret new learning as it happens. It is often personally and socially mediated. This is different from other ways of knowing and doing, such as more

traditional methods of teaching that use more direct instruction methods that promote rote memorization of science material. If science teachers are being expected to teach in constructivist ways, it is incumbent upon teacher preparation programs to teach science content while modeling the appropriate pedagogy which often includes constructivist strategies (Cochran, 2000; Mellado, 1998; Duggan-Haas et al., 2001). This is a complex and often complicated undertaking because pre-service teachers would be taught science content while they are learning about teaching and learning (Duckworth, 1986; Geddis & Roberts, 1998). The role of the teacher education program, then, would be dual in nature. The pre-service teacher would be taught the content through the implicit modeling of the pedagogy exactly as the pre-service teacher would be expected to redeliver it in the science classroom (Duggan-Haas et al.).

The dual role of teaching content while modeling appropriate pedagogy is a departure from the paradigm of science education which has been in fashion for most of the twentieth century: the behaviorist-positivist tradition. This “tradition” prepared teachers to use lectures, worksheets, and “cookbook labs” as their favored method of teaching with right and wrong answers and memorization as the framework. “Reading the chapter, answering the questions and the test on Friday” becomes the routine for the secondary school science classroom. Such teachers typically view their role as the central figure in the classroom who transmits the knowledge in a linear manner with little student input, little attention to prior knowledge, or conceptions and no recognition of the importance of what students bring to the classroom. Their intent is to “cover the material” and get ready for the test.

The typical science teacher preparation program teaches specific content and pedagogy in different classes. For example, biology is taught in the biology classroom and chemistry in the chemistry classroom while the pedagogy is often relegated to the “methods” courses. This often results in a disjointed teacher preparation program with several unfortunate outcomes (Cochran, DeRuiter & King, 1993; Hewson & Hewson, 1988). One outcome, for example, might be that teachers may have a strong content but not have the ability to transform the information in a way that is meaningful to their students (Lederman & Latz, 1993). Another outcome might be that they may have a strong background in one topic but have very little understanding of another science topic, so they are unable to integrate the science curriculum for deep understandings. Students in the undergraduate science classroom have had many opportunities to solve textbook problems, as opposed to real world problems, but may not have had the experience of thinking about how they think or, indeed, that there might be other ways to think about science (Geddis & Roberts, 1998), which may be another unfortunate outcome. It may also be that the teachers have a strong knowledge of pedagogy but do not feel confident about their teaching because they do not have the content knowledge (Munthe, 2001).

According to Stofflett (1998), the majority of undergraduate introductory science courses are dominated by fact-driven instructional models that assume that students are passive recipients of lectures and readings. Their preconceived ideas of science and their naïve mental models are overlooked during traditional science courses with traditional science teaching method. Teachers of science may be ill prepared to teach content in a manner in which students are engaged in appropriate learning practices because they have

not had experiences that engaged them in the process of learning science. They may leave the science courses in their teacher preparation program with “shallow understandings, weak connections between big ideas, trivial knowledge, unchallenged naïve conceptions of how the natural world operates, and an inability to apply knowledge in new settings” (Craven & Penick, 2001, p. 2). Such programs do not often produce teachers who are confident in their ability to teach science with a sophisticated understanding of science that is necessary in our increasingly complex world. When teachers are not confident in their ability to teach well, they tend to return to their experiences in high school and college science courses. The years that teachers have been sitting in science classrooms have helped to shape their teaching practices and habits of minds. Lortie (1975) calls this their “apprenticeship of observations.”

Pre-service teachers only know how to teach by the way that they have been instructed (Hewett, 2003). Current thinking about quality teacher preparation is that it should be based on a model of teacher education that is based on both content and pedagogy (Abell, Volkmann, Arbaugh, Lannin, & Boone, 2004; Darling-Hammond, 1998). The series of courses studied in this research (NSCI 3001, NSCI 3002, NSCI 3003) was intended for pre-service teachers acquiring middle school certification and was designed to provide a model of teacher education that integrated content with pedagogy.

The NSCI series of courses was the result of collaboration between the College of Arts and Sciences and the Department of Middle-Secondary Education and Instructional Technology in the College of Education. The intention was to provide the science content that would be necessary to prepare adequately pre-service teachers in the middle grades and to model the appropriate instructional strategies, technology integration, and

assessment tools that middle school teachers would be expected to implement in their classrooms. The sequence of Physical Science, Earth Science, and Life Science was constructed around the theme of “Science in the Home.” As often as was appropriate, the content was related to science found in the home. For example, when the physics of thermodynamics was being taught during physical science, the topic of how the refrigerator worked was referenced. When studying heat transfer, the differences between the traditional oven and the microwave oven were discussed. The idea was to make science relevant, accessible, and necessary to one’s every day life as well as a cerebral and scholarly pursuit. The content of all three courses was integrated with other areas of science, such as physics, astronomy, chemistry, biology, environmental sciences, and weather. The courses were taught by faculty from the various science departments with input and occasional teaching events by faculty of the College of Education. The courses were designed with an integrative format and a spiraling infrastructure that allowed science concepts to be taught multiple times within the three courses from different perspectives. For example, in physics heat transfer was taught through the explanation of thermos bottles and heat pumps, while in astronomy heat transfer was explained through the study of solar heating during a discussion of the sun.

An extensive website allowed students to revisit lecture information, organize homework, access grades, post “burning” questions and research, email participants and instructors, view the syllabus and preview the rubrics for all projects throughout the series of courses. Lectures were often integrated with the lab (as opposed to many science courses where it is a lab period or a lecture period, but not both). The intention of these courses was to provide an inquiry based, lab-rich opportunity for middle school pre-

service teachers to learn the content of middle school science, have the opportunity to be coached on appropriate middle school pedagogy, and be a participant in the tools for assessment (portfolios, quizzes, tests, technology events and class labs) that would allow them to be prepared to teach middle school. A science project was the culminating project for the NSCI series. Each participant was required to choose a topic of interest, be involved in a science project just as though he or she was a middle school student, and publish/display the findings.

The instructors of this series of courses exhibited their deep understanding of their content through lectures, demonstrations and inquiry experiences. They also modeled the pedagogy appropriate for middle school students (Knowles & Brown, 2000). This intersection of content with the appropriate modeling of pedagogy has been termed "pedagogical content knowledge" (PCK; Shulman, 1986). PCK is that "amalgamation" of where pedagogy and content integrate so that the teacher uses not only the content of a specific subject, but teaching strategies, various representational tools, classroom management frameworks, and organization that makes science a transforming teaching experience (Gess-Newsome, 1999; Magnusson, Krajcik, & Borko, 1999; Shulman, 1987). PCK includes an understanding of how particular topics, problems, or issues are organized, presented, and adapted to the diverse interests and abilities of learners, and presented for instruction (Shulman, 1987).

In this series of courses, unlike many science courses that are typically offered to teachers, content and pedagogy were offered in concert with one another and the participants had access to not only the subject matter but also to the appropriate teaching strategies that would be necessary for them to be confident teachers as they worked with

their own middle school classrooms (Abell, 2000; Konen, 2000; Major, 2002; Shalcross & Spink, 2002). Table 1 represents a comparison of the typical teacher preparation program and the series of science courses, NSCI.

Significance

If teacher preparation programs are to be reflective and proactive while meeting the needs of the students, the pre-service and novice in-service teachers' voices must be honored. Craven and Penick (2001) indicate that exemplary teacher preparation programs have a mechanism for feedback from their students and use that feedback to inform decisions. If teacher preparation programs are to be improved, there must be attention given to the processes by which the teaching knowledge base is developed and transmitted to teachers (Grossman, 1990). The data from this study was intended to present the thinking of novice teachers on a series of courses (NSCI), which was carefully crafted to prepare middle school teachers to teach science. Novice teachers for this study were those teachers who have been teaching for 3 or fewer years. Their descriptions were focused on their confidence to teach science content to their students. This information provided insight into the future development of this particular series of courses.

Rationale of the Problem

As a student of the NSCI series of courses, I attended the lectures, participated in all labs and activities, accessed and interacted with the Website, completed all assignments, and took the tests as a matriculated student. Beyond that, however, I was observing the teaching techniques and the modeling of the instructors as they prepared

Table 1

Comparison of a Typical Science Teacher Preparation Program and NSCI

Typical Teacher Preparation Program	NSCI
Science content taught in discrete topics	Integrated science curriculum
Paper and pencil assessments	Alternative forms of assessment such as projects, demonstrations, papers, as well as paper and pencil tests
Science facts taught in isolation	Science is conceptualized through “big ideas”
Technology not often included except as isolated tool	Technology embedded in all aspects of coursework
Labs and class are separate events	Labs and content are seamlessly integrated
Science taught as direct instruction with lecture being the most prevalent strategy	Inquiry used as part of lecture and labs; activity based instruction
Science content and methods are taught in different courses	Both science content and methods were taught in the same course

the pre-service teachers for classrooms of their own. I noticed that these science instructors from the College of Arts and Sciences were also adept at teaching the content with pedagogy and further related it to the needs of the middle school teachers. They were connecting the curriculum to the state benchmarks for middle school science, promoting inquiry and constructivist methods, and differentiating the instruction. I was impressed by the level of rigor the courses provided as well as the skill level of the pedagogy that was modeled.

As part of a pilot project, I assessed the effectiveness of the courses based on the five core propositions of the National Board for Professional Standards (NBPTS, 2004). I found that

> These courses serve the pre-service teachers well by teaching highly rigorous content, providing inquiry and constructivist activities, structuring multiple designs for learning and modeling effective teaching strategies. The first 3 of the five core propositions are compellingly evident throughout the courses. The last two are less compelling, but visible. Again, since reflecting on ones practice and modeling that through class and being members of learning communities are fairly invisible during the teaching event, they are not expected to be highly evidenced during course time. (Ford, 2004)

I also discovered that these courses changed my understanding of the nature of science, increased my knowledge of the influence of inquiry on the constructivist classroom and, most importantly, improved my practice as a middle school science teacher.

I came to my Ph.D. program from the perspective of an instructional specialist: What concentration would be most helpful for my work with teachers? Because I had expertise in teacher support in other core areas, I chose science as the area that I wanted to emphasize in my graduate study. As a student, I began taking these courses with a bit of trepidation. I knew I did not have the background for the science, and I really had not liked science much in high school and hadn't liked teaching science.

However, as I began to feel more confident in my ability to learn science, I found myself studying harder, reading more widely and speaking up more in class. I began to enjoy the labs and make connections from what I was learning in the science class to my "real life." I began to feel as though I could learn science and even, with more support, be able to teach it appropriately! I felt a shift from my previous science phobia to a feeling of confidence in my science content knowledge coupled with the strategies I had been observing from the instructors.

This progression appears to be confirmed by the research of Crowther (2004) with his work with elementary science pre-service teachers. He finds five stages in college students as they take science courses to prepare to teach science. They first have

reservations about the subject matter. They appear to be anxious and hesitant about new content and processes with which they are unfamiliar. This correlated with what Tosun (2000) calls science phobia, especially among female students. This may be due to lack of previous successful experiences in science classrooms. The second stage involves a new awareness of science content. They begin to make some connections from what they are learning in the lab to their “real lives” and begin actually to enjoy science. The third stage appears to be an intrinsic shift that involves the shift in thinking about science as something they find hard and foreign to something that interests them and with which they can be successful learners. They begin to see that they are not taking the class for the grade, but because they are intrinsically motivated to do well. The work of the students begins to improve in quality and quantity. The fourth stage involves the building of self confidence: As students are successful, their confidence and self-efficacy improves. Because of their belief in their own ability to be successful science students, they continue to improve. The final stage according to Crowther is the empowerment stage where the college students feel confident in their ability to teach and are empowered to implement their new content and information about successful teaching strategies to their own teaching practice. This is exactly the succession that I followed in the evolution of my science teaching philosophy, my growth in my pedagogical content knowledge, and an increased confidence in my ability to teach science to middle school students.

I wondered if my fellow students in the classes had a similar experience. Did they also recognize that we were being taught both content and pedagogy? Did they have a change of understanding about science in the same dramatic manner that I did? As new teachers, did they recognize the valuable experience that I as a veteran teacher recognized

these courses to be? Did it have any effect on their practice in the middle school science classroom? Were there any elements of their teacher preparation including this series of classes that resulted in their feeling confident about their ability to teach science content appropriately? Did they see a connection between what was taught in these courses and their classroom practice in their first years of teaching? These essential questions sustain my interest and passion in this subject and provide my rationale for this problem.

Theoretical Framework

The theoretical underpinning of this study is based on pedagogical content knowledge. PCK involves the teacher's understanding the content of science so thoroughly that he or she identifies ways of representing and formulating the subject matter to make it understandable to others. The teacher who has a strong grasp of PCK uses powerful analogies, illustrations, examples, explanations and demonstrations that promote student understandings that are personally meaningful (Shulman, 1986). "Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult; the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons" (Shulman, p. 9). Teachers must, then, not only know their content, their pedagogy, but also must have a clear understanding of their students' background, interests, learning styles and developmental stages.

PCK is what separates the science teacher from the scientist. The science teacher knows the content but organizes it and thinks about it differently from the scientist. The scientist organizes his knowledge from a research perspective and uses this mental model to develop new knowledge in his field (Cochran, 2000). The science teacher thinks about

the content from the perspective of how best to teach the subject matter in an effective way for their students (Duggan-Haas et al., 2001). According to Shulman (2004a), pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue.

PCK is highly specific to concepts being taught, and it develops over time. A teacher's PCK is in a constant of state of change as he or she moves along the continuum from the pre-service experience into practice in the classroom (McDonnough et al., 2004). It allows the teacher to take his or her content knowledge and transform it for his or her students by critically reflecting on the science topic, interpreting it, finding multiple paths for representing it, adapting it to the students' developmental level, including their abilities, experiences, and finally tailoring the material to meet the need of the students' learning environment (Veal & Tippins, 1998; Wilson, Shulman, & Richert, 1987). It is a transforming process that continually restructures the subject matter for the purpose of teaching so that students deeply learn concepts in meaningful ways (Gudmundsdottir, 1987). PCK is the best knowledge base of teaching as suggested by Shulman:

> The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students. (Shulman, 1987, p. 15)

PCK was the lens through which the descriptions of the novice teachers were viewed.

Research Design

Research is a systematic means of gathering information about actions and interactions, reflecting on the meaning of the data, coming to some conclusions and eventually going beyond the description to making some interpretations (Marshall &

Rossman, 1995). Qualitative research is designed to describe and interpret what can be discovered about a certain phenomenon or subject of interest (Maykut & Morehouse, 1994). Lincoln and Guba (1985) refer to qualitative approach as the emerging paradigm or the naturalistic paradigm. This research involved a case study with a cohort of the NSCI science sequence participants who were novice teachers during the 2006-2007 school year. A case study is a detailed examination of one setting or perhaps a single subject, a single depository or a particular event (Merriam, 1988). In this project the case study was the three courses in the NSCI series and their influence on the key novice teachers.

Multiple data gathering techniques contributed to the trustworthiness of the data. This process is often called triangulation (Glesne & Peshkin, 1992). Semi-structured interviews, a focus group, and a jot-list assignment of teaching strategies learned in NSCI were the data collection tools. Field notes were used to record the data as well as transcriptions of the audio recordings during the interviews and the focus groups. A constant comparative method of analysis (Maykut & Morehouse, 1994) allowed the data to be studied and revisited in an iterative manner. The constant comparative method is one way to conduct an inductive analysis of qualitative data (Lincoln & Guba, 1985). Through constant comparative analysis, I compared “specific incidents in the data . . . refined these concepts, identified their properties, explored their relationships to one another, and integrated them into coherent theory” (Taylor & Bogdan, 1998, p. 137). Member checking provided important feedback for data analysis and provided accuracy of information. A peer debriefer was used to enhance the trustworthiness of the study.

The study consisted of four phases. After the Institutional Review Board provided approval (Appendix A), Phase I began with solicitation for and agreement to be part of the study. (Appendix B). Twenty one contacts were made by using the pool of former NSCI students who had taken all three courses and were currently novice teachers for whom the university had current contact information. The intent was to include three to six participants. Three would provide the minimum amount of data to provide substance to the study and result in data saturation. Six would be the maximum number that would allow the data to be analyzed thoroughly and deliberately considering the constraints of time and effort. Three teachers agreed to be part of the study

Phase II consisted of semi-structured individual interviews (Appendix C) of the three participants who met the criteria of being novice teachers, of having completed all three courses in the NSCI series, and of being willing to participate in the study. The same four main questions were posed for each participant with an additional question to be asked if the participants did not refer to the NSCI series. Additional questions were posed to clarify and expand on participant's responses. At the end of this interview, each participant was asked to reflect over the course of the subsequent 2 weeks about his or her teaching practice. He or she was asked to record any activities, assignments, experiences, or the like that were influenced by their participation in the NSCI integrated science series. This was called the jot-list assignment.

Phase III was a focus group where the participants were involved in further conversation and shared perceptions. A focus group was used because the dialogue among key informants might provide valuable information about confidence, confident teacher practices and influences on the confidence of the novice teachers that would not

have been accessible during an individual interview. Dynamics change when a small group of participants begin sharing information, and this can often result in further rich data for the study. Two questions were provided to initiate conversation (Appendix D).

Phase IV was a member checking event. It is important that I have accurately represented the data provided by the three participants. After the data was organized and analyzed for this dissertation, portions were sent electronically to the participants for their analysis. Adjustments in language or nuance were made in rare occasions and the changes were reflected in the dissertation.

A peer debriefer read and coded all of the field notes and read the final manuscript independently of myself. Dialogue between the peer debriefer and me promoted another level of trustworthiness and credibility by confirming the data analysis of the research as well as asking questions and promoting deeper analysis of the data. This final step promoted confidence in the reliability of the data analysis and reporting.

Human as Instrument

As the researcher, it is incumbent upon me to provide reliable and accurate information acquired through interviews, a focus group, and a jot-list assignment with the NSCI participants who were novice teachers. My experience in implementing a pilot project based on the NSCI coursework has given me the experience of asking research questions, completing a literature review, and acquiring, analyzing, and reporting data in a scholarly manner. As a participating member of the NSCI classroom, I have access to information that might not be available to another researcher. I am very familiar with the instructors' work, assignments, and assessments for the class and the protocols and environment of the overall program. This allowed me to use my knowledge more

efficiently and effectively to implement this study. Having a very limited expertise in science might have been a factor in this study. I was learning the information at the same time that the participants were learning it. This might have been an asset to the study in ways that might not be possible if I had a strong science background; it might be that having similar experiences learning the content added a new dimension to the study.

Limitations and Biases

I recognize that I have a bias in this research project. As an experienced teacher, it was very clear to me that the NSCI series offered both content and pedagogy in a constructivist manner by skilled instructors who were confident in their ability to present their subject matter. Their strategies and activities to promote learning were modeled for the class and pedagogical content knowledge was exhibited by the instructors. I came to this research recognizing that I must be very careful not to project my perceptions and opinions on the key informants of this study. I also recognized that one of the limitations of this study might be that as a fellow student with the participants, they may want to tell me what they think I might want to hear. This is often referred to as a socially desirable response. However, this could also prove to be a benefit. It may be that since the students were my student peers, they were more open to speaking freely. It was my responsibility to question and probe, rephrase questions, and revisit questions in different forms to be sure that the information reported was reliable, accurate, and complete. I had no indication that the participants were anything but absolutely truthful and frank during all conversations.

Summary

The importance of appropriate science teaching in the middle grades cannot be overemphasized. In order for science teacher preparation programs for middle grades teachers to meet the increasingly complex needs of pre-service teachers, it is vital that teacher educators honor the voices of those teachers. The descriptions of the participants in the NSCI series provided important information to the facilitators of the program about how these courses were viewed by the participants. The data were recorded, described and then interpreted to reveal the thinking of the teachers about the coursework and its relevance to them as novice teachers. The descriptions of their confidence in their ability to teach science content was examined through the lens of PCK.

CHAPTER 2

REVIEW OF PERTINENT LITERATURE

The following literature review provided a framework for this study by discussing areas that were germane to the descriptions of the teachers in the study. Teacher preparation is at the heart of any change or reform in science teaching and the standards outlined by the National Science Teachers Association are a necessary framework for science teacher success. Because appropriate teacher preparation should result in teachers who are confident about their abilities to teach, research on confident teaching is included. Pedagogical content knowledge is highlighted because accomplished teachers implicitly and explicitly use these skills to translate scientific principles into understandable concepts for their students. Adult learning theory with an emphasis on learning and teaching styles is included because there may be a connection between adult learning assumptions and the ability of pre-service teachers to absorb and process science information in order to feel confident to redeliver it appropriately. Finally, constructivism as both an epistemology and teacher referent is outlined as a defining attribute in teaching and research.

Teacher Preparation

In the United States, two major organizations have sponsored proposals or visions for science education reform. While the visions of the American Association for the Advancement of Science (1989) and the National Research Council (1996) are somewhat different, they both promote science education that results in a scientifically literate

citizenship. The National Research Council considers the goal of universal scientific literacy for all citizens is for them to be able to use scientific information, to engage in discourse and debate about scientific issues, and to share in the excitement and personal fulfillment that comes from understanding the natural world (p. 1). Although there is some disagreement about what a scientifically literate person actually knows, Abd-El-Khalick and Lederman (2000) state that a scientifically literate individual is one who is able to make informed decisions within a science and technology context by drawing upon scientific knowledge. If that goal is to be achieved, there must be educational reform beginning with the point person: the classroom teacher.

What students learn is greatly influenced by how they are taught according to the NRC (1996). Both the NRC (1996) and the AAAS (1989) standards are based on the philosophy that students are active learners who construct knowledge through their interpretations of the world around them, which is often referred to as “constructivism.” Teacher preparation programs, then, must support the educational reform so that teachers are well prepared to teach their content in appropriate ways that support scientific literacy and the constructivist philosophy of science education reform. In order for teacher preparation programs to be successful, there are many areas that may be considered to influence the effectiveness of the program: two of these, adult learning theory and learning styles will be discussed in conjunction with teacher preparation in this chapter.

Teachers are the critical change agents in paving the way to educational reform and the improvement of student achievement (Ajzen & Fishbein, 1980). Because competent teachers have a direct and positive effect on student learning, it behooves colleges of education to be very serious and intentional about the experiences and

opportunities that are provided for pre-service teachers. Historically, it has been the role of the science education leaders to offer comprehensive suggestions for the teaching of science in our schools. These suggestions involve the what, the why, and the how of science teaching (DeBoer, 2000). The Association for the Education of Teachers in Science (ASTE, 2005) recognizes that “science teachers must possess a conceptual understanding of science, its applications and the history and nature of science. Science teachers must have a strong idea of how students learn best at their level of teaching as well as have the skills and dispositions of an effective teacher” (p. 1).

Teacher education programs should focus on practices that are grounded in research such as those reflected by National Science Education Standards (NRC, 1996) and Project 2016 (AAAS, 1989). The teacher graduates of such teacher education programs should have the skills and knowledge of their subject matter as well as the appropriate pedagogy. Teacher graduates must have the skills to be critical thinkers and reflective practitioners (Yore, 2001).

The goal of teacher education, according to Fenstermacher (1986), is to educate teachers to reason soundly about their teaching as well as to perform skillfully. Teachers, then, will need both a process of thinking about what they are doing and a base of facts, principles, and experiences from which to reason. He posits that teacher preparation programs must work with the beliefs which guide teacher actions and principles because these are the basis of the choices they make in the classroom. These beliefs and principles must rest on a foundation of adequately grounded premises (Fenstermacher).

In the education of teachers, it is vital that adult beliefs and teacher beliefs be considered in any educational opportunity and, in this case, teacher preparation programs.

Teacher beliefs are precursors to change (Ajzen & Fishbein, 1980). The beliefs that adults hold are the best predictors of future decisions and behaviors. People regulate their level and distribution of effort in accordance with the effects they expect their actions to have (Bandura, 1986). Pajares (1992) indicates that beliefs form attitudes and attitudes ultimately inform decisions that teachers make in the classroom. His findings on beliefs include the following:

1. Beliefs are formed early and are often self-perpetuating. They are preserved often in spite of reason, experience and schooling.
2. People develop a belief system that incorporates all of their beliefs acquired through cultural transmission.
3. Beliefs have a priority based on connections and relationships to other beliefs.
4. Beliefs that are formed early are difficult to change; the longer one has held the belief, the more difficult it is to change.
5. Adults rarely alter their belief system.
6. Beliefs influence perception.
7. Beliefs influence behavior.
8. Teaching beliefs are well established once a student attends college.
9. Beliefs play an important role in defining tasks and selecting tools for solving problems, planning and making decisions. (Pajares as cited in Ballone & Czerniak, 2001, p. 8)

The beliefs of those making decisions about teacher education have resulted in four paradigms, according to the work of Zeichner and Gore (1990), that have dominated teacher education in the United States: “behaviorist,” “personalistic,” “traditional-craft,” and “inquiry-oriented.”

The behaviorist paradigm has had the most influence on the educational institution. It is founded on a positivist epistemology and a behavioral psychology that emphasizes a list of observable skills that are linked to higher student achievement. In this paradigm, the teacher is prepared to perform a basic set of teacher behaviors that will

promote learning in the classroom and result in a highly productive classroom (Dias, 2000).

Personalistic teacher education promotes the improvement of self and is built upon developmental psychology. In this paradigm, the needs of the teacher are self-identified and the teacher education program is built around their concerns and their needs as adult learners (Zeichner & Gore, 1990).

The traditional-craft paradigm views teaching as a craft learned primarily from an apprenticeship view. Teachers learn their craft from others as they watch others perform. Although not as prevalent or influential as behaviorism, it is certainly apparent in the practicum experiences and typical student teaching experiences used in teacher education programs today (Zeichner & Gore, 1990).

The final paradigm described by Zeichner and Gore (1990) is the inquiry-oriented paradigm. This approach involves the use of inquiry as well as the skills of teaching. The teacher uses the skills of teaching not as an end to themselves, but as part of the whole picture of effective teaching. Inquiry-oriented approach has been around since the 1950s, when DeBoer (1991) promoted the concept in science education. There are many ways that inquiry teaching can be described. Some have called it “hands-on learning” or “hands-on, minds-on learning” or experiential learning or activity-based instruction. While there may be elements of all of these in inquiry, inquiry is much more than making sure all students are engaged in cognitive tasks. Inquiry involves the active search for knowledge or understanding to satisfy a curiosity (Haury, 2003). While some teachers in the inquiry-centered classroom may prefer to start with the exploration without direction and others prefer to have more structured methods of guided research, the ultimate goal

of inquiry is to research an idea or event, describe, and interpret the data and report the findings. The central feature of the inquiry-oriented classroom is the initial curiosity or wondering that invites the exploration.

The research on teaching which informed teacher preparation programs over the last century has evolved in nature and focus. In the 1940s and 1950s in the United States, teachers were often evaluated on presage variables (Danielson & McGreal, 2000). If teachers were pleasant and well dressed, knew a bit about their subjects, and were upstanding citizens, they would most likely be considered effective teachers even if there were not data to support this. In the 1960s, research, especially in the area of math and science, began to center around students' skills acquisition and researchers were developing assessments based on clinical observations and teacher effectiveness "behaviors" or "teacher effects." Teachers were being prepared to exhibit certain teacher behaviors which would result, the notion went, in improved student achievement. Madeline Hunter's (1982) work with prescriptive teaching practices, based on a very behaviorist paradigm, emphasized time on task, teaching for transfer, anticipatory sets and the like, which are still very much a part of the culture of schools today. Many school systems and colleges of education used Hunter's seven-step lesson plan, and teacher evaluation was often dependent on the teacher's following this lockstep plan. As the 1990s approached, there was more worry that students would not be prepared for the 21st century. The research of the 1980s had emphasized the importance of the teacher in the classroom and set up the next wave of teacher education which moved from the behaviorist paradigm to the cognitive learning arena and then on to what many refer to as constructivism. This teacher research emphasized the social nature of learning, the

importance of context and prior knowledge, the need for involving students in higher order thinking skills and the belief that students can construct their own meaning from experiences. Building on the knowledge of the "teacher effects" research of the 1980s, the last decade of the 20th century moved teacher education from teacher behaviors being the focus (input strategies) to focusing on the students and their understanding of the content and its application (output strategies). Research on how students learn has influenced the body of knowledge about teacher education. It is now recognized by most in the colleges of education that there is interdependence between the content students learn, the methods by which the content is taught, and the ways in which students are assessed (Danielson & McGreal, 2000).

Unfortunately, there has often been a disconnect between colleges of science and colleges of education. Some teacher education programs appear to be fragmented. Students take content courses in their first two years and then take methods courses in their last two years and culminate with student teaching. The content course instructors and the methods course instructors typically do not communicate with one another and the teacher preparation program and the science courses do not support the agenda of one another (Beckmann et al., 2001). Typically undergraduate science courses are taught by lectures, fact-driven instructional models that assume that students passively receive information, and textbook assignments. Constructivist learning theory disputes this assumption, indicating that students bring with them strongly held conceptions about the subject matter that they use as filters for new information (Stofflett, 1998).

The research of reports such as one conducted by Salish in 1997 of teacher preparation programs indicates that the faculty from outside the schools of education did

not often feel a need to be involved in teacher education. The colleges of education did not always have nor want to have a clearly articulated philosophy of education. The means of instruction in the science teacher education program did not always meet the standards of the National Science Teachers Association, teachers in the program did not see a connection between what they were being taught in their coursework and what was being advocated in the science community and the faculty in the science department and in the teacher education program found the science teacher education program to be lacking in coherence (Salish).

Duggan-Haas (1998) indicates in his work that there are two distinct programs and cultures in the world of science preparation and science education preparation. His work with the Salish I Research Project researching the relationship of teacher education and the relationship of how new science teachers teach has resulted in three areas where he feels there is a strong contrast between the culture of the science classroom and that of the teacher education classroom. He calls these the "weeding out" of the science classroom versus the "nurturing" of the teacher education classroom, "meritocratic" in the science classroom versus the "democratic" of the teacher education classroom, and the "masculine" of the science classroom versus the "feminine" of the teacher education classroom. His research indicates that the education classroom has well defined goals that are well understood and there is content to be learned and that content is well specified. The mode of delivery of this content is typically lecture with a few labs. Classes are typically large with little use of cooperative learning and an over dependence on the textbook. Assessment is mostly objective tests with a preponderance of multiple-choice items. The faculty-student relationship is one of "aloofness" and was not considered to be

warm and inviting. The teacher education classroom, on the other hand, did not always have well defined nor well understood goals. Group work was typically involved with some lecture although that was typically shunned. Readings and collections of articles were often used as the basis for the course and assessment was often written essay along with teacher performance in and out of class. Undergraduate teacher education courses often reflected how and what teachers should teach in their own classrooms (Duggan-Haas). The cultures of the college of science and the college of science education are very different from one another and are often in opposition to one another. This results in teacher candidates who may often be conflicted, who see science as one paradigm and science education as another (Duggan-Haas). Tobias (1990) reports that students are often discouraged from taking science courses because of their lack of relevance to the students' lives, passive student roles, emphasis on competition, and focus on algorithmic problem solving.

What then can be done to support college science educators as they strive to become more effective at teaching science to future science teachers? Change will not occur unless there is dissatisfaction with existing conceptions of science teaching. There must be a systemic culture that encourages the skills and knowledge that the faculty bring to the classroom and leadership must be more flexible and personal to adjust to the faculty as they make changes in their paradigm and in their practices (Sunal, Wright, Hodges, & Sunal, 2000). There must be a collegial atmosphere that encourages collaboration, not competition. How then must higher education institutions proceed? The first step is to overcome the barriers identified by Sunal et al. as resources, time and turf conflict. These may not be barriers that can be overcome by the individual instructor, and

change in higher education is perceived as occurring outside the person and beyond immediate control. Although systemic change is a goal for reform effort, the place to begin to make immediate and measurable change is at the course and instructor level and to overcome barriers within the instructor's personal control, such as personal resistance to change, lack of training, and curriculum materials (Sunal et al.). Workshops for the college instructors with the appropriate follow-up, experts, and peer consultation, and the use of action research in the classroom of the college instructor have been measures that have proved somewhat successful in implementing strategies to provide more effective science instruction (Sunal et al., 2000).

Craven and Penick (2001) suggest that there are several features of a science teacher educator program that will be considered exemplary and provides a framework for a science teacher preparation program. One of these features includes collaboration among college programs. While Shulman (1986) was referring to "Great Conversations" as the dialogue among disciplines about teacher research, it may well be applied to those conversations about teacher preparation (Beckmann et al., 2001). If there is to be a seamless education for future teachers, there must be an intensive and purposeful collaboration among faculties of both colleges. In the case of science education, this would be a dialogue between the college of education and the science department in the college of arts and sciences. It must be clear what the role of each department is in this collaboration and in all teaching events the instructional strategies must be consistent with the goals of the educational program as well as the National Science Education Standards (NRC, 1986).

Another feature would be the clear articulation of the goals and philosophy of all stakeholders and strategies must be put in place for the achievement of these goals. There must be coherence in the teacher education program that allows for all personnel being aware and supporting the effective practices that promote well-prepared, confident teachers and that are aligned with the professional science organizations as well as meeting the standards of the science community (Craven & Penick, 2001).

Science students come to the college classroom with years of experience observing teaching but also with years of experience observing science. They have formed their own misconceptions and preconceptions (Geddis & Roberts, 1998; Lortie, 1975; Roberts, 1998), and this affects both the teachers' and their future students' knowledge acquisition (Beijaard & Verloop, 1996; Collinson, 1996; Rhine, 1998). The science educators then must be aware of their students and model for their pre-service teacher students the "habits of mind" that allows for inquiry, discussion, debate, exploration, articulate of beliefs, and time to analyze how their beliefs may affect their teaching (Craven & Penick, 2001). Just as the student in the science classroom is constructing new knowledge about science, the beginning teacher is actively constructing his or her knowledge and understanding about science and science teaching (Lortie; Luft & Patterson, 2002) and must be actively involved in his own learning (Lilly & Sirochman, 2000).

The teacher educator may well be served by becoming a facilitator in the classroom. The work of Craven and Penick (2001) indicates that the roles of the facilitator educator are to know how students learn, use expertise to structure an environment that promotes meaningful learning, purposefully design tasks that lead to

conceptual understanding, promote professional attitudes and foster reflective practice and use assessments that inform instruction yet cultivate meaningful strategies for learning by students. As the teacher educator interacts with his or her students, he or she will listen for their misconceptions, probe and prod for the students to support their conceptions of science and lead them to cognitively appropriate strategies to stretch their thinking, revisit their beliefs, and provide scaffolding as they process their own conceptual change (Craven & Penick).

Craven and Penick (2001) indicate that the classroom environment for the pre-service teacher must be one that allows students to at times be overwhelmed or confused. Dealing with feelings of "ambiguity" will allow students to face the feelings that their future students may experience. Dialog about how to deal with these issues in their college classroom and then in their own classroom as a teacher will allow them to confront their own concerns. It will also allow them to support their own students in a constructivist classroom that promotes the student as the leader. For many of them this may be an unfamiliar role. This learning environment will also promote collaboration among students to solve authentic real world problems. Student centered approaches to science education are promoted, and there is an attitude of collegiality between students and teachers. Students must feel free to negotiate the authority structure in the classroom so that more emphasis is placed on student ideas and interests. The environment of the teacher educator's classroom must be one that involves a risk-free environment that allows students to express ideas, test their developing theories and apply their understandings. Teachers who are involved in this model of education are more likely to

model it in their own classrooms. This is how classrooms and teachers are transformed and educational reform and goals may be achieved in the area of science education.

An equally important feature for an exemplary science teacher preparation program, according is Craven and Penick (2001), is the establishment of a series of courses that promote rigor, higher order thinking skills, and inquiry. According to Yore (2001), a fundamental part of every teacher education program must be the development of critical thinking where pre-service teachers are challenged by pedagogical issues, required to find alternative solutions, and required to reflect upon and justify their instructional decisions. The assessment and instructional strategies promoted in the coursework must be consistent with the goals of the program. There must be a component of research in the program as well as teaching and learning events. Research will allow science teacher preparation programs to produce teachers who are

> critical thinkers and reflective practitioners and to help practicing teachers to develop the critical stance and strategies necessary to become reflective practitioners. This involves more than just mimicry, mechanical use and classroom management of inquiry science teaching. (Yore, p. 5)

A cohort approach to the science program will facilitate a support group, a sense of community and retention of teaching candidates in the program.

Another feature of a teacher preparation program outlined by Craven and Penick (2001) promotes the balance of theory and practice. The students in the program have opportunity for experiences both in the learning location and the teaching lab. The students are, also, included in other entities in the science program such as business, informal science centers, and governmental agencies.

A final component that is considered vital for the future excellence of science teacher educator programs is there must be a mechanism that provides feedback for the

outcomes of the program. This feedback must then be used to inform the practice and modify the program. Science teacher educators must be well-informed about their programs in order that all decisions are evidence based (Craven & Penick, 2001).

Craven and Penick (2001) suggest several types of evidence that may be collected and included in an assessment of a science teacher educator program. Compiling a data base of graduates of the program to track the graduates will provide information about where students are (if they are teaching), and information from school administrators and district officials may indicate how they are teaching. There must be a dialogue among the instructors in the program, recent graduates, and, if possible, students of the new teachers and their parents. Allowing former students to provide their feedback and perceptions about the program is an invaluable tool for making informed decisions about the coursework. Another piece of feedback about the program may be performance measures, such as portfolios, videotapes, or feedback from observations.

What now should the emphasis be in the middle school science teacher preparation program? Middle school science educator instructors must have a deep knowledge of curriculum, instruction, and assessment in order to support the science teachers they are preparing for middle grades instruction. It is also important they have an understanding of how middle grade students learn science best (Abell, 2000). For pre-service teachers to be adequately prepared, their teacher educators must not only have an insight into their adult learners' background in the science content area, but also model the appropriate strategies for teaching the science content (Dejong, 2000; Lowery, 2002). While it appears intuitive that science content knowledge would be the most important issue for science teachers, research indicates that it is pedagogical knowledge that

appears to be more directly related to student achievement (Foley, 2004; Marzano, Norford, Paynter, Pickering, & Gaddy, 2001). Teachers who have been in teacher programs where specific strategies are modeled in their content courses and have been given opportunities for application and active learning appear to have a higher level of self-efficacy which results in the teacher's perception that he or she can affect change in the classroom (Marzano et al.). It is also very important that the instructors model good teaching practices because adult learners are more easily influenced by seeing what to do as opposed to being told what to do (Bruce & Showers, 1988). In fact, modeling may well be the most important element of good teacher preparation (Brooks & Brooks, 1993) The "apprenticeship of observation" in the exemplary teacher preparation program will support the pre-service teacher in such classrooms (Lortie, 1975). This enculturation into the science education classroom requires some effort on the part of the science educator.

The work of Gee (1990) indicates that there is a distinction between acquisition and learning in the enculturation of the student. Acquisition is the process of subconsciously acquiring information based on exposure to models, having the opportunity to learn by trial and error, and practicing within social groups without formal teaching. This is how people often acquire languages, cultural rules, or the mores of a culture. Learning, on the other hand, is a process that involves conscious knowledge gained through teaching or through certain life experiences that promote reflection. This may or may not be a result of a formal teacher, but it will often involve some degree of meta-knowledge about the content. Gee would say that acquisition will precede learning and apprenticeship will precede teaching. This results in the teacher student's being

enculturated into becoming a science teacher by first learning it by “doing” it (Roth-McDuffie, McGinnis, & Watanabe, 1996).

An example of enculturation is found in a study by Konen (2000). His work indicated that the use of hands-on training for pre-service and service teachers resulted in feedback from teachers that stated that their anxiety about teaching difficult science concepts decreased and that their confidence levels to redeliver the material increased after attending inquiry-based hands-on workshops. These results reinforce the value of learning content integrated with lab time in the same manner that the pre-service teachers would be redelivering the material to students.

It is important that the pre-service teachers are able to be exposed to content and pedagogy that will produce deep understandings on their part so this information can be provided in the future in an accurate, efficient and engaging manner (Duggan-Haas et al., 2001).

Leonard’s (1989) work with labs in college science courses confirmed that participation in inquiry labs results in students who are more involved, allows students to have more responsibility, require more extensive use of science process skills, produces significantly greater educational gains than traditional approaches and appears to work equally well for college students of all ability levels. His results reinforce the necessity for enculturation in the educational program of the pre-service teacher.

Learning to teach is a complex and difficult task. One reason for this according to Shulman (2004a) is that unlike other professions where the discipline is used as a basis for practice, in teaching the disciplines play a dual role. The instructor must not only know the subject matter, but must understand it well enough to teach it to someone else.

Teaching is far more than telling. It takes practice, it takes feedback and it takes instruction. A second reason is that the teacher educator must overcome all of the negative examples of teaching that were in the pre-service teacher's background from preschool to baccalaureate. Teachers who have been less than stellar provide modeling as well as those who are excellent at their craft. Another reason for the difficulty of learning to teach is because teaching is so dependent on learning from experience and unless teacher educators and teachers themselves think about their teaching in intentional ways, learning from experience is very difficult. A final reason identified for the difficulty of teacher preparation is the influence the content teachers in the university have on the future educator. He indicates that the content teachers must be aware of their influence and take responsibility to model appropriate teaching practices as well as the teaching of the content (Shulman, 2004b).

> . . . future teachers in those arts and sciences classes are not simply going to learn (content) for themselves. Every misconception, every incomplete idea, every less-than-inspired example of pedagogy ends up living in them to be transmitted to others. The students in your arts and science classes are carriers. They will take along what you have taught and transmit it with great fidelity to those whom they teach (Shulman, 2004c, p. 156).

The apprenticeship of observation in the preparation of teachers, then, must be intentional and appropriate for future teachers.

Standards for Science Teacher Preparation

The National Science Teachers Association (NSTA, 2003) Standards for Science Teacher Preparation are based on reviews of professional literature and on the goals and framework for science education in the National Science Education Standards (NSES; (NRC, 2003). The NSES is a visionary framework for science teaching in pre-college education which assumes that scientific literacy must be a primary goal of science

education at the pre-college level. These ten standards (NSTA, 2003) outline the vision for what excellent science teacher preparation should look like.

Standard one involves the mastery of content. Teachers of science must have an understanding of the knowledge and practices of contemporary science. They must be able to understand and convey to students the major concepts, principles, theories, laws and interrelationship of their fields. In addition they must be able to convey the unifying concepts of science, the personal and technological applications of science, understand research and successfully design, conduct, report and evaluate investigations in science. In addition, they must be able to use mathematics to process and report data and solve problems in their fields of expertise.

Standard two involves the nature of science (NOS) in science teacher preparation programs. Teachers must be able to demonstrate that they understand the historical and cultural development of science and the evolution of knowledge in their discipline. They must also be able to understand the philosophical tenets, assumptions, goals and values that distinguish science from technology and must be able to engage students in successful studies of the nature of science. Explicit instruction is needed to prepare teachers to grasp the nature of science themselves and to lead their students to understand the concept (Abd-El-Khalick & Lederman, 2000). Science teacher programs need to include components of the nature of science and its importance on teaching and understanding the discipline and concepts of science. This is crucial in order for teachers to be prepared to promote a scientifically literate society through their classrooms. If NOS is not included in the pre-service program, it may result in teachers using inquiry practices that require a more naive or limited PCK. As teachers gain more experience in

teaching and laboratory experiences, they will be more effective and then as they become more scientifically literate will truly teach for scientific literacy (Eick, 2000).

Standard three involves inquiry as a strong component of the science teacher preparation program. Teachers must be able to understand how to encourage students to ask questions, design inquiries, collect and interpret data in order to develop concepts and find relationships from their empirical experiences. Inquiry experiences may lie on a continuum from discovery learning where the teacher sets up the problem and processes but allows students to analyze and report their own data all the way to student generated, student analyzed and reported experiences. Teachers must be prepared to structure inquiries effectively in their classrooms. In order for such effective inquiries to be implemented, they must be explicitly modeled in the pre-service classroom.

Standard four involves the science teacher's being able to understand social issues, how they are related to science and technology, and how they affect society. Science teachers must be taught how to engage students in the analysis of problems in the area of science that relate to the knowledge, goals, and values of their students. Explicit attention to such important topics as cloning, weapons development, stem-cell research, and other controversial 21st century topics must be given in the teacher preparation program so that teachers are well prepared to guide their students.

Standard five involves the general skills of teaching. The science teacher preparation program must provide coursework that allows their teacher candidates to demonstrate their ability to vary their teaching strategies based on the needs of their students. Instructors will be aware of their own learning style and promote activities that support the learning style of their teacher candidates. One of the most important roles of

the instructor is to help their students build a repertoire of strategies that will appeal to all the learning styles which will be represented in their future classrooms (Ouellette, 2000). They must understand the importance of acceleration, remediation and accommodation for the cognitive levels of their students. The importance of prior knowledge, preconceptions and misconceptions must be emphasized in the classroom of the science educator, and strategies such as cooperative learning and the use of technology must be modeled by the instructor. Future teachers must understand the importance of creating and maintaining a psychologically and socially safe and supportive learning environment.

Standard six involves the use of curriculum. Teachers of science must be able to demonstrate that they understand the units of study in the curriculum that has been provided by their local education group. Well-prepared teachers are able to plan, implement, and assess important units of study and use the appropriate materials, resources, and activities based on the objectives of the lessons. During course work on teaching and curriculum there must be multiple opportunities to learn and practice the information to provide for a seamless entry into the first year of teaching.

Standard seven involves science in the community. Using community resources is an integral part of any science program. The science teacher educator program must provide many opportunities for the teacher candidate to be involved in activities that will align with what they will be expected to do as a classroom teacher. Field trips, special speakers, service learning, nature preserves, and the like will be valuable experiences for the teacher candidate.

Standard eight is the effective use of assessment in the science classroom. The science teacher preparation program must model the newest research in assessment and

evaluation in its program. Multiple assessment tools and strategies must be presented and their use and modification in the classroom must be taught. Explicit instruction in the use of peer assessment tools as well as self-reflection tools will enhance the ability of the science educator to promote fair and equitable assessment in their own classrooms. Teachers must be confident in their ability to use a wide range of assessment tools with a focus on authentic assessment strategies.

Standard nine outlines the teacher candidates' demonstration of the legal and ethical responsibilities of science teachers concerning their students, animals in their care and the maintenance and disposal of materials. Teachers must know the safe and proper techniques for preparing, storing, dispensing and disposal of all materials used in the science classroom. They must also be aware of emergency procedures, how to maintain equipment in a safe manner and how to treat all living organisms in a safe, human, and ethical manner. These matters must be directly and intentionally addressed in the science teacher preparation program.

Finally, standard ten involves the professional growth of the science educator. A part of the coursework of the teacher candidate must address the importance of engaging in continuous professional learning through coursework, interaction with colleagues and professional organizations, science literature and aligning with professional organizations. An opportunity to become involved with the local science professional organization, for example, would be another mechanism for building community among the pre-service teachers that would promote professional growth.

These ten standards provide a framework for rigorous coursework and field experiences that will promote accomplished teaching and a scope and sequence of opportunities for pre-service teachers.

Adult Learning Theory

Andragogy, according to Malcolm Knowles (1980), is the "art and science of helping adults learn." Others have described andragogy as a "theory of adult learning," "a theory of adult education," "a theory of the technology of adult learning," "a method of adult education," and "a set of assumptions concerning adult learning processes from which we can derive a number of injunctions concerning appropriate teaching methods" (Brookfield, 1986). No matter which definition is used, an understanding of how adults learn is an important concept if meaningful learning is to occur.

Adult learning theory begins with the assumption that adults learn differently from child learners (Knowles, 1980). The biggest assumption, perhaps, is that early learning is formative while adult learning is often transformative (Mezirow, 1991). Adults come to their learning events, both formal and informal, with a variety of background experiences that will affect their progress, their depth and breadth of learning, the rate at which they learn (Knowles, 1980), and even how they integrate new learning into their schemas and understandings. This may inform how they make decisions and act upon these new understandings (Mezirow).

Knowles's (1980) work is based on five assumptions: that as adults mature, their self-concept moves from dependent to more self directing; that adults have a growing reservoir of experiences which is a rich resource for learning; that adults' readiness to learn is related to the tasks with which they are involved; that adults are more problem

centered; and that adults are motivated to learn by internal, rather than external factors (Merriam & Caffarella, 1999).

Self-directedness as opposed to teacher directedness is an important feature of adult learners (Merriam & Caffarella, 1999). Self directed learners desire to take a leadership role in their own learning. Adult learners prefer a participatory learning experience where they are involved in goal setting for the learning experience, plan the curriculum, diagnose their own learning needs, identify resources, and devise strategies for accomplishing their objectives. Adult instructors can help learners organize the learning and model as they teach new skills, but it is up to the adult learner to do the learning. Asking students about their goals and objectives or finding out what their needs are results in the students not falling back in to old habits from high school and their early years of college when they were “dependent” learners who depended on the teacher to be in charge of the learning (Knowles, 1980).

The greatest resource in the classroom of the adult learner is the rich reservoir of experience brought by the learner. Prior knowledge and life experience allows the adult educator to structure activities that cause the adult learner to integrate new knowledge with existing schema. In fact, the need to make sense out of one’s life experiences is often an incentive for seeking further education in the first place. Adults use new learning to integrate with their life’s experiences to modify, transfer, reintegrate meanings, value, strategies and skills (Merriam & Caffarella, 1999). Therefore, learning strategies such as experiential learning, problem solving, case studies, class discussion, and the like are appropriate strategies to take advantage of the collective experiences of the adult learners as they honor what the students bring to the context of the learning.

Adult learners appear to learn best when they are involved in job-related problems, have a choice in content and process of learning, and are involved in collaboration for solving problems (Tennant & Pogson, 1995). Adult learners must perceive the goals and objectives of their coursework as achievable, realistic and relevant to future goals. Adult learning is often self-directed and autonomous and involves discussion both in whole group and in small groups that allow them to think and rethink their philosophy and apply what they have learned (Brookfield, 1986; Zepeda, 1999). Motivation for learning will be enhanced as the instructor provides clear goals and engaging learning activities that are tailored to the individual learning needs of the students and that allow for individual pacing. Motivation can be inhibited when there is little personal contact among participants, only passive or transmissal forms of teaching are used, few examples are provided in class that illustrate concepts, criticism is covertly and/or overtly expressed of participants, and students feel stupid for asking questions (Pike, 1989).

Because adults are often competency based, it is helpful to allow adult learners to apply their new skills in class and then, if possible, implement them in their own practice. Knowles (1984) outlined seven elements called the andragogical process design, that allows the adult learner to be involved in determining what he or she is to learn. They are climate setting, involving learners in mutual planning, involving participants in diagnosing their own needs for learning, involving learners in formulating their own learning objectives, involving learners in designing learning plans, helping learners carry out their learning plans, and involving learners in evaluating their learning.

Adult learners appear to prosper in programs that balance theory with practice. According to the research by Joyce and Showers (Galbo, 1998), 5% of learners will transfer a new skill into practice as a result of theory alone. Ten percent will transfer news skills into practice as a result of theory and demonstration of the new learning, 20% will transfer a new skill into applied practice if theory, demonstration, and practice are conducted within the training, 25% will transfer a new skill with theory, demonstration, practice, and feedback, and 90% will transfer a new skill into use if theory, demonstration, practice, feedback, and ongoing coaching is provided.

The adult educator will best serve his or her students by establishing a climate of humanness, both physically and psychologically. Arranging seats so that all participants can view one another, promoting respect and trust among the participants, establishing collaborative modes of learning and providing support for learning in an atmosphere that indicates that learning is fun and engaging will allow the adult learner to feel that education is attainable (Brookfield, 1986). Instructors must be aware of the backgrounds of their students and address issues of diversity, such as learning style, ethnicity, race, gender, sexual orientation, and/or culture (Merriam & Caffarella, 1999). Relationships are of prime importance to the adult learner. There must be a psychological climate that is comprised of mutual respect, collaboration, trust, support, openness, authenticity, pleasure, and humane treatment (Knowles, 1980). It is the responsibility of the facilitator to provide the atmosphere.

This experience with complex, meaningful interaction promotes knowledge in a way that practicing isolated bits of information cannot. Skills and knowledge are best acquired in context. The task for adult educators then must be to provide experiences that

allow adults to form their own means of transferring information, to apply new learning to their own reality "schemata," and to apply new knowledge to their own real lives (Knowles, 1980).

Assessment for adult learners is a topic that must be considered when discussing andragogy. While educators of adults are often willing to model appropriate andragogy (student input, purposeful assignments and the like), there appears to be a disconnect when considering assessment. A study described by Beaman (1998) of hundreds of adult learners indicated that grading and evaluation methods used by adult instructors was not consistent with the facilitator, constructivist teaching models used in the class and this resulted in a disconnect between instruction and assessment and the instructor and the student. Because the goal of evaluation or assessment should be learning and because adults often prefer learning which is empowering and instructors who are more facilitative, alternative assessments may prove successful with the adult learner. Beaman (1998) outlines several alternative assessment methods that work well with adult learners and maintain the alignment between instruction and assessment. One alternative assessment that she proposes is a method called "praiseworthy grading." This method shifts the focus from what is wrong with the paper (a deficit model) to what is right or praiseworthy (an additive model). The instructor would spend a great deal of time giving feedback on papers that would be well done and less time on those papers that are not as well done. While inaccuracies and other mistakes are pointed out, the focus is on what the student does well. The idea is to direct the adult learner to their successes. When the additive model is used for grading, students consider the grades an expression of

appreciation for their work instead of depreciation. This allows adults to work in a risk-free environment where collaboration, not competition, is encouraged (Beaman, 1998).

Whether it targets children or adults, assessment is always a difficult task. However, if assessment is provided during an adult learning activity, it must be aligned with the overall philosophy of adult learning theory that allows the adult learner to maintain a sense of dignity. Adult learners must be assessed for evaluative purposes, but also for motivation and feedback. Traditional grading methods may not always work with adult learners and may need to be amended.

In addition to adult learning theories, it might be fruitful to discuss a theory of stages that college students may experience that was developed by Perry (1998) in the 1960s and traces the intellectual growth of college students. His work involved a series of open-ended interviews with Harvard undergraduates that resulted in nine different "positions" from which students view the world of learning. He rated levels of undergraduates from least mature to higher levels of maturity through four stages which he calls dualism, early multiplicity, late multiplicity, and contextual relativism.

Dualism involves the idea that there are right and wrong answers to every question and that it is the job of the teacher to provide the "truth" and be the source of all knowledge. Students would see their roles as information receivers and demonstrators of the knowledge they have received. Disagreement with the authority would not be even thought of: Beliefs systems are given by the authority (instructor) and would go unanalyzed and unquestioned (Kurfiss, 1983).

Early multiplicity implies that students are beginning to realize that some of life's answers cannot be either right or wrong, but may be dependent upon the situation. The

student still thinks that the instructor should be modeling the process of learning and he thinks his job is to learn the information and to work hard to master the subject matter.

Late multiplicity begins when students start to discern and value evidence as opposed to mere opinions and feelings. Students begin to judge a teacher by how well they model good thinking processes. They begin to value thinking for themselves and use objective evidence to support their thinking. Students may, according to Perry (1998), go overboard at this stage and believe that one opinion is as good as another and they can cite evidence to support any opinion. This stage may occur around the sophomore year (Kurfiss, 1983).

Contextual relativism is the stage that allows student to distinguish reliable information and substantive evidence from the “ideals of infallibility and absolute truth” (Perry, 1998). At this stage knowledge is seen as contextual and decisions are reached by reasonable thinking practices. The teacher becomes a resource and an organizer as opposed to the authority. Students begin to recognize that their role is to gain and apply knowledge rather than to acquire facts and produce duplicate versions of the teacher’s lectures. The stages move much like Piaget’s from “concrete and simplistic to abstract and complex thought processes; from absolute to relativistic belief systems and from external to internal controls as the student increasingly reflects upon and takes responsibility for actions, choices, and the selection /formulation of a world view” (Kurfiss, 1983, p. 18).

Ideally, the soon to be college graduate has progressed through all these stages and exemplifies this last stage in his or her learning continuum. However, because the world is not always ideal, it is important for adult educators to provide experiences that

will allow for growth. One such strategy, according to Perry (1998), is for students to become participants in a "community of scholars." Students and faculty would be involved in a variety of learning and social events where they share information, engage in critical analysis and empathetic discussions, and reflect on ideas, information, and choices (Perry). There is some evidence that students who are engaged in such environments of respect progress more rapidly than those who do not (Dinsmore & Wenger, 2006; Kurfiss, 1983).

Learning and Teaching Styles

Adult learning theory is informed by the learning style preferences of the adult. Learning styles are often described as preferences that the learner exhibits in how to acquire information, how to practice or engage in the content, and how to be assessed or evaluated on the content. Learning styles appear to be different from intelligence, ability, and personality and integrate cognitive organization and mental representation (Riding & Rayner, 1999). Although learning styles are preferences that are dynamic and may change based on situations and can change over time, most people maintain a preference for a particular learning style throughout their lives (Ouellette, 2000).

Learning styles or cognitive styles can be traced back to the personality model created by Hippocrates that included the melancholic, the sanguine, the phlegmatic, and the choleric. Myers and Briggs (1962) developed learning styles indicators that were used for their version of this learning style concept. Carl Jung (1971) studied four types of learning styles in his work and introduced the concept of extraverts and introverts. He derived these two preferences from his observation of people and their interest in an object or the subject. He proposed that each person has some measure of both

extraversion and introversion. Extraversion, he explained, was the outward flow of energy to an external object, and intraversion was when the conscious content refers to the subject. He further divided these two types into a four quadrant learning styles concept which included the idea of thinking, feeling, sensation, and intuition (Bennet, 1983).

There are several learning style models which incorporate preferences of modalities, organization preferences, processing preferences, and intelligence or skills preferences. The National Science Education Standards (NRC, 1996) indicates that one of its main principles is the notion that science is for all students and that curriculum must be designed to meet the interests, abilities, experiences, understandings, and knowledge of students. If a teacher believes that all students can learn, he or she accepts the belief in the diversity of learning styles. Acceptance of diversity of style creates an atmosphere that encourages a student to reach his or her full potential (Guild & Garger, 1985).

One learning style model is based on the work of Carl Jung (1971) and is authored by Hanson, Silver, and Strong (1996). This model includes the belief that a learner takes in information in one of two ways: through sensing it (five senses) or through intuition (seeing a larger picture). The model is also predicated on the concept of how one processes the information: either through feelings about the information or through thinking about the information. According to Hanson et al., a person who takes in information through sensing and processes it through feelings is called a *Senser-Feeler*. This learning style is composed of those students who prefer to talk about the information with partners or small groups, prefer information to have personal relevancy, and are more successful when they are able to articulate their learning either orally or in

writing. Those who take acquire information through senses and process it through thinking are called *Senser-Thinkers*. These learners prefer to write it down in a very linear way, prefer notebooks or handouts, and learn best when they are able to be active participants in the learning through taking notes or reading and outlining the chapter. Those who acquire information through intuition and process it through thinking are called *Intuitive-Thinkers*. They prefer activities that allow them to think through the information, explain, debate, and analyze content. The fourth group, *Intuitive-Feelers*, is made up of those who prefer to acquire information through intuition and process through feelings. This group of learners prefers to be involved in performances and products and learn best when they are actively involved in engaging activities. The functions of the four types of learners described by Hanson et al. may be expressed in different ways depending upon whether they are introverted or extroverted (Guild & Garger, 1985).

Anthony Gregoric’s (1979) work with learning styles reveals that some learners prefer concrete experiences while others prefer abstract experiences. He calls the continuum of learners’ preferences with these features Abstract to Concrete. He also suggests that the human mind prefers either sequential or random ordering the information. This results in four learning styles which are Concrete-Sequential, Abstract-Sequential, Concrete-Random and Abstract-Random (Gregoric). A self-analysis tool called the Gregoric Style Delineator is used to identify an individual’s learning style preferences.

Kolb (1984) described an experiential learning model that also outlines four different preferences for learning. They are convergers, divergers, assimilators, and accommodators. Convergers acquire knowledge by thinking and analyzing it, and then

apply the new ideas. They organize information through deductive reasoning and are typically very rational and concrete. Divergers acquire knowledge through intuition. These learners use their imagination and their ability to view complex situations from many perspectives. They are able to integrate small pieces of information into meaningful "wholes." Assimilators learn by thinking and analyzing, and then they plan and reflect. Their emphasis is on creating models for their learning, not necessarily application. Accommodators are those learners who will get things done; their motto is "just do it". They learn best by trial and error and acquire information from others (Kolb).

McCarthy's (1987) work with her 4MAT program provides for four learning styles and how these four quadrants represent the variety of ways a students might approach a learning situation, process the information, and transform the learned information (Ballone & Czerniak, 2001). The 4MAT system permits students to fall on a continuum from Active Experimentation to Reflective Observation. McCarthy indicates that Type I learners are brainstormers who prefer to become personally involved with the content and have a need to see its relevancy in their lives. They see information from a concrete or sensing manner and process it reflectively or with feelings. They constantly want to know why this is important for them to learn. Type II learners are those who take in the information very analytically and are interested in facts and details and prefer to master the information. Type III learners process information actively after they perceive it in an abstract way. They are interested in understanding information at the conceptual level. Type IV learners are risk takers; they are interested in self-discovery and have a desire to learn by trial and error. McCarthy indicates that successful teachers structure lessons that appeal to all of these types of learners throughout the course of the lesson or

unit. Wheeler (1988) indicates that the work of Bernice McCarthy and the development of her 4MAT system is seen to have an impact on the teaching and learning styles in the science classroom. Teachers are exceptional at meeting the needs of the Type II learners. However, meeting the needs of the other styles is vital if teachers are to meet the needs of the other 75% of the learners in the science classroom (Ballone & Czerniak, 2001). Science teachers who are able to teach to the individual learning styles of their students are meeting the needs of those individual students while at the same time exposing all students to diverse strategies (Wheeler, 1988).

The learning styles models indicated above are focusing on the processing of information. Howard Gardner (1999) with his Multiple Intelligences Theory emphasized that human beings view the world in eight ways: verbal-linguistic, logical-mathematical, bodily-kinesthetic, musical, spatial, interpersonal, intrapersonal, and naturalistic. His multiple intelligences theory asks the question “How are you smart?” as opposed to many educational programs that ask “How smart are you?” (Gardner, 1999). He posits that these intelligences are really a cognitive model that seeks to describe how individuals use their intelligence to problem solve.

Felder and Silverman (1988) have formulated a learning style model that appears to align with science education specifically and involves the use of style and intelligences. They contend that a students learning style may be defined by answering five questions:

1. What type of information does the student prefer? Sensory (sights, sounds) or Intuitive (memories, ideas, insights)
2. Through which modality is sensory information most effectively perceived? Visual (pictures, diagrams) or Verbal (sounds, written or spoken word or figures)

3. With which organization of information is the student most comfortable? Inductive (facts and observations are given with underlying principles inferred) or Deductive (principles are given and consequences and applications are deduced)
4. How does the student prefer to process information? Actively (physical activity or discussion) or Reflectively (introspection)
5. How does the student progress toward understanding? Sequentially (logical progression) or Globally (large jumps, holistically) (Felder & Silverman in Felder, 1993, p. 286)

The point in the science classroom is not to determine each student's learning style and then to teach it exclusively. A good teacher addresses each learning style dimension at least some of the time. If this could be accomplished, then students could be taught in a manner that sometimes matches their learning styles, thereby promoting effective learning and positive attitudes toward science (Felder & Silverman, 1988).

Academic achievement is elevated when students are instructed through their preferred learning style. Okebukola (1986) found that students perform better in an environment that matches their preference. Results of his research with biology students demonstrate that the students who showed a preference for cooperative work achieved significantly better in a cooperative learning environment than those who were mismatched, that is were taught in a style other than their specific learning style preferences (Okebukola).

Students whose learning styles in the college classroom are compatible with the teaching style of the course instructor tend to retain information longer, apply it more effectively, and have more positive post-course attitudes toward the subject than do their counterparts who experience learning/teaching style mismatches (Felder, 1993). The learning styles of students can allow them to have the potential to become excellent scientists and excellent teachers of science.

Teacher Confidence

Teachers with strong confidence are not discouraged by challenges: They consider them to be things to be overcome. They often attribute failure to lack of effort or not having the right knowledge base and recover quickly from setbacks. Teachers who have low confidence levels have weak commitments to goals, find many excuses for failures and are slow to recover from them (Bandura, 1994).

Bandura (1994) has identified four major psychological processes through which self beliefs of efficacy affect human function. One of these is cognitive processes. Much of what humans do is dependent on forethought and goal setting. The stronger the feeling of confidence, the higher the goal challenges are set and the stronger the commitment to reaching those goals. People with strong cognitive belief systems construct and rehearse scenarios in which they succeed; those who have weaker cognitive belief systems rehearse failure scenarios and think about all of the things that can go wrong. It requires a strong sense of efficacy to remain focused on the tasks at hand when challenges arise: Those who do not have firm confidence in their ability to perform become less focused, lower their expectations of themselves and their production decreases (Bandura).

Another key player in the role of confidence is motivation. Cognitive motivators center around causal attributions, outcome expectancies, and cognized goals. People who have strong feelings of self confidence attribute their success to effort and their failures to lack of effort. Those who are less efficacious blame themselves for not having the ability to do well. Outcome expectancy theory is regulated by the idea that a given course of action will produce certain outcomes and those outcomes can be predicted. Those who have strong belief systems of confidence will participate because they believe that they

can do something; those without those strong beliefs will not participate because they feel that they cannot be successful. Cognized goals allow people to set high and challenging goals for themselves, and self-satisfaction is the incentive for reaching the goals (Bandura, 1994).

Affective processing involves coping capabilities in the face of threat. Those with strong feelings of self-efficacy are able to face stress and danger more positively, are able to control their disturbing thoughts, and are able to overcome feelings of helplessness. Those with less firm self-beliefs will have feelings of loss of control, danger, high anxiety arousal, and depression; some biological dysfunctions; and avoidance behaviors.

Finally, selection processes determine the level of self-efficacy. Peoples' choices in life help them to create healthier and happier environments. The higher the feelings of self-efficacy or confidence, the wider the score of choices people have. Those with high confidence levels also tend to take more risks, feel capable of making choices that are challenging, and better prepare themselves for the challenge. Those with low confidence levels avoid activities and situations that they find stressful or that are above their coping capabilities (Bandura, 1994).

This confidence in the science classroom is often expressed by the use of pedagogical content knowledge and constructivist teacher practices that are evidenced by student engagement, enthusiasm, content mastery and a continued thirst for knowledge (McDonnough et al., 2004).

Effective teachers affect student learning. Teachers who have confidence in their own teaching abilities persist longer, provide a greater focus on instruction in their classroom, and are involved in different types of feedback than those who have lower self

expectation of their ability to influence student behavior and growth (Gibson & Dembo, 1984). A study by Inman and Wesson (1998), where 60 nontraditional science students in the United Kingdom were asked about their teaching experiences, indicated that the lack of self-confidence and a low self-image were among the greatest difficulties to overcome in their initial year of teaching. Confident teachers have as their goal increased student achievement (Joyce & Weil, 1996), and they are more likely to promote it in their students (Tschannen-Moran, Hoy, & Hoy, 1998). This appears to happen because confident teachers try new strategies more often, are unfazed by initial setbacks and are reflective overall about their teaching practices (Ashton, 1984; Wong, 1997). They are able to integrate new teaching practices that had been shown to promote growth in students (Sparks, 1988). Studies have documented that strong self-efficacy beliefs are linked to high student achievement and increased student motivation (Ashton & Webb, 1986; Henson, 2002; McDonnough et al., 2004).

Confident teachers are able to teach to the subject matter, but they also understand the needs and interests of their students, anticipate their misconceptions, articulate the metaphors of the subject matter, use more appropriate examples, and adapt the material to meet the needs of their students (Cochran, 2000).While uncertainty is a natural part of a teacher’s professional work, teacher uncertainty can be in part related to their lack of confidence in their subject matter (Munthe, 2001). Teachers who have a deep science understanding are able to use student-centered, inquiry teaching methods more efficiently. When they do not have a deep science understanding, it leads to low self-efficacy, and this may result in teachers who return to rote learning methods that do not necessarily result in high student achievement. Teachers who lack confidence teach more

conservatively, tend to follow the book, do not use inquiry, and do not involve students in activities that promote deep understanding (Basista & Mathews, 2002; McDonnough et al., 2004; Petish & Davis, 2001). They also are reluctant to change their teaching practices and try new research-based instructional approaches and do not deem themselves capable of improving student achievement. They often gave up on their students without attempting to enhance their learning (Sparks, 1988). Adult learners who are confident are more likely to continue taking courses and will enhance their knowledge of their own content knowledge (Norman & Hyland, 2003). Insufficient competence compromises the ability of the teacher to teach his or her subject matter well. (Bobek, 2002)

There are some studies that indicate that teachers who have confidence in their ability to teach science do not always have a deep understanding of science nor do they necessarily have students who had high student achievement. The TIMSS (Mullis, Martin, Gonzalez, Gregory, & Gardner, 1999) report included results from an index of teachers' confidence in their preparation to teach science. Teachers were asked to indicate how well prepared they felt to teach each of 10 science topics. The participants could state they were very well prepared, somewhat prepared, or not well prepared. If a teacher did not teach one of the specific topics, the teacher could indicate that and the results were excluded from the report. Overall, teachers reported only moderate confidence in their preparation to teach science. Approximately 20% of students on average internationally were taught by teachers who believed they were very well prepared and 41% by teachers who were somewhat prepared. The three highest performing countries based on student achievement, Hong Kong, Japan, and Korea, more

than half the students had teachers who felt only somewhat prepared or less. Science teachers in the United States generally reported greater confidence among countries included in the study although the student achievement scores were not among the highest. Only the Czech Republic reported greater confidence from their teacher data than the U.S. teachers. Teachers in the United States overall expressed greater than average confidence in their preparation to teach topics in earth science, environmental and resource issues, and scientific methods and inquiry skills. Despite an apparent high level of confidence in their preparation to teach science, teachers in a number of the lower-scoring jurisdictions reported relatively high levels of confidence in their preparation. This may be attributed to a science curriculum that is not very demanding, according to the report (Mullis et al., 1999).

A study conducted in 2004 compared pre-service teacher's science concepts knowledge to their self-efficacy beliefs using the Science Teaching Efficacy Belief Instrument (STREBI-B). This study indicated that Turkish pre-service science teachers had a generally high confidence level but also had low-level conceptual understanding in science. In fact, although these teachers held many misconceptions about science, they were generally optimistic about their ability to teach science (Tekkaya, Cakiroglu & Ozkan, 2004). In summary, while some studies indicate that teacher confidence results in high student achievement, there are also studies that find a negative correlation between science content knowledge and self-efficacy and student achievement.

Confident Teacher Practices

Effective teaching is the byproduct of a skilled, thoughtful individual who becomes expert at the art and science of teaching. Such teachers understand how to make

decisions concerning best practices in their classroom performance (Marzano, 1992). For science teachers to be successful with their students they must understand not only their content but also the processes of science and science instruction (Duggan-Haas et al., 2001). They must have knowledge and understanding of the key concepts and how they relate to the curriculum and understand the processes of learning that allow pupils' growth to be promoted (Gooday & Wilson, 1996). Effective science teachers ask questions, engage students actively, concentrate on the collection and use of evidence, provide historical perspectives, insist that students articulate their answers clearly and with appropriate support, collaborate, structure for vocabulary understanding and not just memorization, reward creativity and inquisitiveness, and promote a spirit of questioning more often than do their less successful counterparts (AAAS, 1989).

This marriage of both content and pedagogy, knowledge with process, results in the current emphasis on constructivist teaching. The teacher in the constructivist classroom provides inquiry-based instruction which is central to science instruction. Connections are made between prior experiences and understanding and the new experiences (Llewellyn, 2002). Teachers in the constructivist classroom encourage their students' autonomy and initiative and use those processes of science that allow students to question their own paradigms and philosophies of scientific thinking. Confident teachers in the constructivist classroom will structure their classrooms so that students are encouraged to ask the questions, formulate their own student inquiry, nurture the students' natural curiosity, and encourage discussion. Confident constructivist teachers, then, will become good listeners as well as good talkers (Brooks & Brooks, 1993).

Effective, confident teachers are skilled in selecting the objectives, teaching to the objectives, monitoring and adjusting when they see that learning is not taking place, and knowing the principles about motivation, pacing, and increasing productive behaviors (Cummings, 1980). They engage students in “robust cognitive and social tasks” (Joyce & Weil, 1996) that allow students to take the lecture and teacher guided activities to a higher level that helps them to make the subject matter their own.

The confident constructivist teacher takes that a step further by ensuring that the design of all activities engages students in inquiry and purposeful learning that are based on true learning objectives, not just fun activities. The teacher and students become, in fact, true learning communities. Teachers in these classrooms have a strong command of their subject matter and understand the particular pedagogical techniques to teach the subject matter (PCK) and are able to anticipate misconceptions that students will make. They understand that misconceptions are simply the result of students trying to make sense of their world and sometimes using information from movies or stories that reinforce their misunderstandings (Lleweylyn, 2002). They understand that learning may occur best when events require some change in the schema of their students. There may be a partial discrepancy between their existing schema and their new experience (Sparks, 1988).

Confident teachers understand that it is sometimes necessary to go beyond the ordinary forms of instruction, lectures, labs and ordinary texts to allow students to change their misconceptions: the use of refutational texts, for example (Guzzetti, 2000), the teacher taking on the role of facilitator rather than the traditional role as classroom

director (Keble & Howard, 1994), or the use of conceptual change theory (Ridgeway & Dunston, 2000).

The confident teacher also becomes adept at asking deep, probing questions that force students to become actively engaged in the discussion and provides relevant and authentic feedback. Student choice, classroom flexibility, and activation of prior knowledge indicate that the teacher is both knowledgeable about the subject matter and confident in his or her belief in teaching it (Danielson 1996; Sparks & Hirsch, 1997).

Expert, confident teachers demonstrate use of higher order questioning, wait time, and varied and contextual assessment that promote student understanding and also emphasize their own continued growth of their subject matter (Varella, 2000). The ability to get students actively engaged and excited about school is another mark of a great teacher. Dewey's (1916) philosophy of active learning and problem solving must result in an active classroom where experimentation and authentic problem solving drive instruction. Piaget's (1977) belief in constructing knowledge when prior experience and new experiences are merged will result in classrooms where a new concept is explored through hands-on experiences before being introduced to the terminology and vocabulary associated with the concept (Llewellyn, 2002). His work with the four stages of intellectual development—sensorimotor (birth to 2 years), preoperational (2-7 years), concrete operation (7-11 years) and formal operational (12 years to adulthood)—indicates that middle school students are most probably in the concrete and/or formal operations (Piaget). While students at this age are beginning to think more abstractly, test out new hypotheses, and think about what they know or do not know (metacognition), they still need many concrete experiences with hands-on activities and manipulative events.

Students in middle school may move back and forth from one stage to another and need extra support from their teacher (Knowles & Brown, 2000). As they construct their own schemas about the presented knowledge they will make sense of the information through assimilation and accommodation. This is very important in the educational life of middle school students.

Vygotsky's (1962) tenets will result in confident teachers allowing for scaffolding and support as they teach their lessons. When the work is just beyond the students' level of independence but can be attained with teacher success (zone of proximal development), students feel just the right amount of challenge (Llewellyn, 2002). Tasks must be challenging, yet do-able in order for the student not to be bored or frustrated (NRC, 1996; Tomlinson, 1999).

The "relaxed alertness" that Caine and Caine (1994) describe reinforces the concept of the learning being "just right," neither bored nor anxious. Bruner's work with motivation and interest suggests that when a student is engaged and interested in the topic, he or she is more likely to be an autonomous learner (Llewellyn, 2002). Ausubel's (1968) work with prior knowledge will inform the practice of confident teachers as they ascertain what students already know about the subject. Students will persist in doing work when they see their work is significant and has rigor and challenge (Schlechty, 1997).

In the classrooms of confident teachers, assessment practices are closely related to instruction. While tests and quizzes may be viable forms of assessments on many occasions, rubrics that allow the students and the teacher to negotiate what excellence looks like allow students to be engaged in both the learning and the assessment. All

instruction must begin with how the information will ultimately be assessed, beginning with the end in mind (Covey, 1989; Wiggins & McTighe, 1998). According to Knowles and Brown (2000), meaningful assessment is constructed by student goal setting, allows students to demonstrate what they know, allows for flexibility, provides opportunities for self evaluation, encourages metacognition, creates authentic connections and permits students to build on strengths and weaknesses.

Experiences That Produce Confident Teachers

Teachers who are confident in their ability to teach science often have had experiences that have promoted their self-efficacy. Self-efficacy beliefs often determine how people act, think, feel and motivate themselves (McDonnough et al., 2004). Experiences that support growth of self-efficacy include mastery experiences (repeated success increases the expectation that I will succeed once again). These experiences, especially if they include challenges, result in the knowledge that sustained effort makes one stronger. Another source of self-efficacy is having experiences that are vicarious in nature (I see that you enjoy this, and I can learn from your experience). Modeling by teachers who are similar to the observer allow the observer to gain strength from the knowledge that they, too, have the capabilities to be successful at certain activities like teaching. Verbal persuasion (I notice that you are good at what you do) is another source of self-efficacy. When other teachers and stakeholders encourage teachers by remarking on their ability to teach, it results in a personal sense of self-efficacy or confidence. Finally, emotional arousal (Good or bad experiences affect ones performance) is a source of self-efficacy (Bandura, 1977). Teachers' expectations often affect their performance (Tschannen-Moran et al., 1998).

Cantrell, Young, and Moore (2003) concluded that teacher preparation programs should focus on the four strategies for increasing efficacy. They suggest that future teachers should be provided with early and a variety of field experiences that include science lesson planning and delivery, collaborate with extracurricular sponsors of activities like science fair and Science Olympiad to get pre-service teachers involved, provide many opportunities for mastery experiences in teaching science and develop a community of learners within methods classes that provides safe climate for risk taking. Although their work was with elementary teachers, it appears intuitive that it would support the work of middle grades teachers as well.

Science students (adults) expressed increased confidence after teaching a topic only once in their classroom in a study by Finlayson, Locke, Soares, and Tebbutt (1998), which indicated that confidence grows as one learns on the job. Studies in the United Kingdom (Shalcross & Spink, 2002) indicated that there was a direct link between confidence, content, and competence. The number one way to increase teacher confidence according to this series of studies was for the teacher to actually teach the subject matter.

The work of Wong (1997) indicates that teachers with a strong sense of self-efficacy have developed it from experiential bases of effective teaching; they perceive themselves to be very capable of getting students to learn. The second best way to improve confidence was to be involved in formal discussion about content and pedagogy with other teachers along with informal discussion with peers and tutors. The teachers also indicated that they wanted more content knowledge taught by “transmissal methods.” Their data indicated that they were more competent teachers when they were

confident with their subject matter. The teachers indicated that they were very constructivist in their classroom practice, but they preferred more traditional transmission of materials themselves. They indicated that this was because they were processing the information themselves in a constructivist manner and because they were more sophisticated learners.

Pedagogical Content Knowledge

The work of Shulman (1986) indicates that it is the intersection of content knowledge, pedagogical knowledge, and pedagogical content knowledge (PCK) that results in an expert teacher. Pedagogical knowledge refers to the general principles of instruction that provide for learning time or feedback and classroom management and typically involve what researchers have prescribed as teacher practices that lead to higher student achievement (Grossman, 1990). Content or subject matter knowledge includes not only knowledge of the major facts, but also knowledge of the substantive and syntactic structures of the discipline. Substantive structures of any discipline refer to the organization of the field and questions that guide its inquiry. The syntactic structures refer to the understanding of how knowledge claims are evaluated and what overriding structures provide evidence or proof in that discipline. An understanding of subject matter knowledge influences the way teachers align curriculum, how they orient their subject matter, and the level of discourse and questioning in their classrooms (Schwab, 1964).

Shulman (2004a), in his work with research on teaching, identified seven headings for a knowledge base in the scholarly study of teaching: content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical knowledge,

knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes, and values. Shulman states:

> Among those categories, PCK is of special interest because it identified the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized represented and adapted to the diverse interests and abilities of learners and presented for instruction. (p. 85)

He and his colleagues in the *Knowledge Growth in Teaching* project proposed that accomplished teachers, teachers who are confident in their ability to teach concepts and principles, have a strong command of their content knowledge, understand the effective practices of teaching that subject matter, recognize their teaching context, and are able to synthesize and translate their understanding into a specific subject understanding. This special way of understanding is an amalgam of content and pedagogy and is referred to by Shulman and his colleagues (Grossman, 1990; Shulman, 1986) as pedagogical content knowledge and has been found to be in important ingredient in the classrooms of exemplary teachers (Tobin & Fraser, 1990).

PCK is often described as being composed of four different components. The first component involves the teacher's purposes for teaching the subject matter to the particular students he or she is assigned. This component is evidenced in the goals of the teacher for specific content. The second component involved knowledge of students and their conceptions and misconceptions for specific topics. It involves the understanding on the teachers' part of the students' prior knowledge and experiences. This is implicit in the work of McEwan's (1987) idea of "pedagogical interpretations," in which teachers interpret subject matter based on student's background and interest. A third component of PCK is curricular knowledge. The understanding of what curriculum scope and sequence is necessary for deep understanding of the content, the resources that are available and

both the horizontal and vertical implications of the curricula is important to complete curricular knowledge. The fourth element involves instructional strategies and representations for particular subject matter (Grossman, 1990).

PCK is highly specific to concepts being taught, and it develops over time. It allows the teacher to take their content knowledge and transform it for his or her students by critically reflecting on the science topic, interpreting it, finding multiple paths for representing it, adapting it to the students' developmental level, including their abilities, experiences, and finally tailoring the material to meet the need of the students' learning environment (Veal & Tippins, 1998; Wilson, Shulman, & Richert, 1987). It is a transforming process that continually restructures the subject matter for the purpose of teaching so that students deeply learn concepts in meaningful ways (Gudmundsdottir, 1987). It is the best knowledge base of teaching as suggested by Shulman:

> The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students. (Shulman, 1987, p. 15)

PCK is the experienced teacher or the talented novice teacher's way of knowing subject matter in a way that allows them articulate a "narrative way of knowing" it; they consider what they know about their subject matter as having a "storied nature" (Gudmundsdottir, 1991b). Teachers often learn and teach knowledge through stories or cases. Cases are rich descriptions of classroom or real world events that emphasize or illustrate a theory or idea. Teachers with a strong grasp of their subject use such stories, episodes or narratives to enrich, expand and make connections for their students between science principles and authentic experiences (Schneider & Krajcik, 2002).

The content in PCK must be reorganized so that the needs of the teacher and the students, the available resources, and the mandates of the curriculum are addressed. The content does not and cannot stand in isolation. The strategies that the teacher chooses to teach that content indicate the value the teacher places on types of learning and also on how that content is best represented (Gudmundsdottir, 1991a). This is often referred to as “teacher orientation.” Teacher orientation involves the teacher’s conceptions of the purposes both of the content and the methods for teaching. One teacher in a science classroom might think that the facts or the vocabulary are the major issue, depending on that teacher’s “orientation,” while another teacher’s belief system emphasizes the teaching of scientific processes. A teacher’s orientation, belief system and purposes for teaching, informs many, if not all, decisions teachers make in their classroom. How they teach, what they teach, when they teach and, even, if they teach certain subjects often depend upon the orientation of the teacher.

Part of pedagogical content knowledge is the understanding of the organizing theory of science merged with an ability to incorporate modes of inquiry into the classroom. This understanding has four possible sources: years of sitting in the science classroom, subject matter knowledge, teacher education, and classroom experience. It is incumbent upon the teacher preparation program to provide experiences both in content courses and methods course that will allow the pre-service teacher to teach in constructivist ways even if they do not have memories of constructivist science classrooms in their own personal background.

> . . . if the focus of subject-specific methods courses is on innovative practices, the courses will need to overcome the knowledge and beliefs teachers have already developed through the apprenticeship of observations. If teacher education has had a strong impact, then what

> teachers learn from subsequent experiences in classrooms may be shaped by prior coursework; if teacher education has been a weak intervention, its lessons are likely to be overwhelmed by classroom experience. (Zeichner & Tabachnik, 1981, p. 8)

Cochran et al. (1993) expanded on Shulman's model and aligned it with more constructivist thinking. Their model involves four major components of pedagogical content knowledge: subject matter knowledge, pedagogical knowledge, teacher's knowledge of students and the knowledge of the environment in which students must operate (Cochran et al.; McEwan, 1987).

Grossman (1990), in her work on teacher education research, uses subject matter knowledge, general pedagogical knowledge and pedagogical content knowledge with another element: knowledge of context. These four areas are the building blocks for her model of teacher knowledge.

The work of Veal and Tippins (1998) indicates that teachers acquire PCK in differing types and degrees. In their microgenetic case study with two prospective chemistry teachers, they discuss several types of PCK: general pedagogical knowledge, domain specific pedagogical knowledge, and content specific pedagogical knowledge. General PCK is more specific than pedagogy because it is specific to science in this case. An example of domain-specific PCK would be what one might need to teach chemistry and content-specific PCK would be what one might need to teach about the mole (Veal & Tippins). Their findings indicate that content-specific PCK occurs before domain-specific PCK and that prospective teachers developed understandings of science teaching that would help serve as building blocks for further acquisition of domain-specific PCK. They further indicate that middle school science program could emphasize domain-specific and general PCK in the methods courses. They find that it "might be important for the middle

school teacher to know more about the integration of science domains, rather than specific topics within domains that may never be taught during the school year" (p. 41).

Jegede (2000) studyied 183 science and math trainee teachers. The teachers were given a 60-item instrument that surveyed their ideas of what they needed to know in order to become expert teachers. The conclusions were that this group of teachers wanted to know more content knowledge, more pedagogical content knowledge, and more about teaching theories and their use. An interesting and optimistic outcome of this study was that the novice teachers had very high expectations for expert, confident teachers.

In Major's (2002) work with college faculty knowledge about PCK, he found that student learning is at the heart of PCK. To help college students learn, the professor must understand who his learners are. This study that involved faculty at a private university in the southern United States found that the understanding of PCK by the faculty and the applying of the concept to their teaching practice resulted in a paradigm shift from a teaching paradigm to a learning paradigm where the goal of all teaching is to enable the learner. Faculty members began to listen to their students, tried to understand their background and needs, ferret out how they think about science and about learning in general. They began to view teaching and learning as an iterative process (Major).

One of the differences between novice and expert teachers in the area of PCK is that experienced teachers have a better defined framework for reorganizing their subject matter. Novices have not had the experience of defining their "orientation" to the subject matter. Orientation in this context refers to the values teachers place on the curriculum, what they believe important for the students to learn, and their understanding of how their students will learn it best. They need time to integrate their understanding of the subject

matter with the pedagogical strategies that reinforce their orientation to the subject matter (Cochran et al., 1993; Geddis & Roberts, 1998; Gudmundsdottir, 1991a).

As a science student, the pre-service teacher often comes to the college classroom with a paradigm that indicates that science has all the right answers. His or her learning orientation emphasizes that there is a right and wrong answer to every problem, and if one just uses the right algorithm or the scientific method, all of the research will be accurate and clear cut according to the science community. For teachers with this orientation, what Roberts (1998) calls the “solid foundation” is the most important: *Do the students have a basic foundation of the content? If not, I must teach them the basics and they better get the idea.* This learning orientation may serve the science student well, but it doesn’t translate into effective science teaching. In fact this strong commitment to the subject matter may result in teaching to the content so strongly and so directly that the student is not given the opportunity to come to any sense of the content himself or herself. (Cochran et al., 1993; Geddis & Roberts, 1998).

Lack of pedagogical knowledge (Shulman, 1986) in the novice teacher often results in resorting to using low-level strategies of instruction such as factual and simple recall questions (Cochran et al., 1993). The novice teacher may find it difficult to articulate how to merge their pedagogy and content knowledge and find it difficult to translate their knowledge of content, even when it may be considerable, to concepts and ideas which are understandable to their students (Carlsen, 1987; Cochran et al.). Novice teachers are more likely to begin teaching without an understanding of their students’ prior knowledge or experiences, their students’ preconceptions or misconceptions or their students’ learning preferences (Carlsen; Wilson et al., 1987).

Not only is the amount of content knowledge a difference between the expert and novice teacher, but so is the way they use their knowledge. Expert teachers are more adept at integrating their knowledge base with their teaching context and practices (Beijaard & Verloop, 1996; Collinson, 1996).

Constructivism

Piaget, sometimes known as the Father of Constructivism, based his theory of constructivism on the following three principles:

1. Knowledge is a result of ever-changing interactions between students and their environments;
2. Intelligence is constantly being constructed from new and prior experiences;
3. Cognitive growth is self-regulating within the individual and the interaction of the physical and social environment. (Piaget, 1977)

These principles form the framework of constructivist epistemology and methodology in the science classrooms today and are further expanded by the following:

1. The active learner (Dewey, 1916) needs to be involved. In fact, the learner must use all sensory stimuli and then make meaning out of his reaction to that input. Teaching and learning should be active and based on the interests of the students and should be personally meaningful.
2. As we learn we are in fact learning new strategies about learning. An example might be that as we complete a chart on the endocrine system, we are learning about the endocrine system as we learn about the educational tool of graphic organizers. This new skill will transfer to other learning episodes.

3. Students must be involved in reflective learning (Dewey, 1916) as well as physical learning. Although hands-on activities (behavioral engagement) are important, the student must be cognitively involved as well.
4. Language is crucial in the constructivist approach. Vygotsky would say that language and learning are inextricably entwined (Slavin, 1997).
5. Learning is social. The interaction among peers, older students, teachers, parents, school workers, etc. allows students to make connections in their world. Cooperative learning and group projects allow students to learn new information as well as new strategies for information (Slavin, 1997).
6. Learning happens within a context. We do not learn isolated facts, but rather learn new information that connects with our personal knowledge base. Bruner’s emphasis on discovery learning is often a part of the constructivist classroom (Slavin, 1997). Ausubel’s (1968) work with prior knowledge indicates that the most important single factor that influences the learning of any student is what the student already knows.
7. Learning takes time. Our brains need processing time in order to make meaning from stimulus. Students need time to process, revisit, and reflect on stimuli in order to find its more significant meaning to them (Jensen, 1996).
8. Learning must be motivational. In the constructivist classroom students are given reasons for learning, given choices and options about how they learn and interesting and engaging activities that will allow them to learn

based on their personal interests. Students need to be able to align personal goals with instructional goals through mediated choice (Jensen, 1996).

9. The curriculum in the constructivist classroom is designed to support natural inquiry. Students are guided in discovering schema and finding self-regulatory strategies that will support their learning. Scaffolding is provided to allow students to work beyond what they might be able to do independently. Vygotsky's idea of the zone of proximal development underlies the need for this support (Llewellyn, 2002).

10. Experiences are provided that allow for error filled (and forgiven) experiences through open-ended play, collective activities that might involve both large and small group activities and that allow for choice on the part of the student.

Overall, in the constructivist classroom the teacher is the guide who moves from *in*struction to *con*struction. There are many subgroups of constructivism and they are called by various names. For this work, two will be identified: radical and social (Gredler, 2001). The radical constructivism based on the work of Piaget considers knowledge as adaptive. The teacher in this constructivist classroom would be involved in metacognitive models for the students so that they can consider different ways of viewing, devise situations that would challenge students' basic beliefs which might result in disequilibrium, and guide students in discovering strategies and knowledge that will allow them to return to balance (Gredler). The work of von Glasersfeld (1993) holds that the "mind and its constructs are the only reality."

The social constructivist recognizes that knowledge is, in fact, a social product that is a result of new stimulus coupled with a student's environment, developmental level, and knowledge base. He also acknowledges that knowledge evolves through negotiation in a community that allows for social discourse. Finally, a social constructivist would state that the product of the stimulus and the evolving knowledge result in learning or a "product" that is influenced also by culture and history (Gredler, 2001).

There are four further subgroups of the social constructivist: the cognitive tools perspective, the idea-based social constructivist, the emergent approach, and the situated cognitive perspective. The cognitive tools perspective is based on a model that emphasizes hands-on, project-based teaching. The idea-based social constructivists based their educational arena on major important ideas that have the potential to transform the lives of their students. The emergent approach appears to be used as needed. Emergentists would state that throughout an educational episode the students would actively construct knowledge through the physical and mental action and that learning best occurs during times of conflict, confusion and surprise. An example of this might be "top-down learning" (Slavin, 1997) where students solve problems by discovering the knowledge needed to perform the task. The situated cognitive model indicates that the learner and the environment cannot be separated; one learns how to learn as one learns (Gredler, 2001). Mediated learning is an example proposed by Vygotsky (1962) that would emphasize the idea that students should be given complex, difficult, realistic tasks and then be given support or scaffolding to be able to be successful at those tasks (Slavin, 1997).

At the heart of the constructivist classroom is the notion that learning is a process that allows learners to construct their own knowledge and make meaning from their own experiences (Dejong, 2000). In constructivist classrooms students are encouraged to generate questions, proffer new ideas and articulate scientific beliefs. This student input is accepted, valued, and encouraged by the teacher and used for curriculum planning. The teacher used many designs for learning such as reflective pairs and cooperative learning, to promote the social aspect of learning. Cooperative learning (Johnson & Johnson, 1991) emphasizes the positive results for learning when students are able to interact, to have positive interdependence and both group and individual accountability. This interaction promotes a community of learning that allows for increased cognitive activity, social construction of knowledge and collaborative inquiry. Reflection and analysis are emphasized as instructional strategies in the constructivist classroom in order to allow students to be self-regulated, self-sufficient learners (Craven & Penick, 2001; Yager, 1991).

Reflections of the nature of science are promoted in the constructivist classroom by giving students the structure where they are able to test, refine, retest, provide explanations, communicate their understandings, and defend their new learning through the use of scientific discourse. This discourse promotes meaningful learning and promotes critical thinking skills (Chinn & Waggoner, 1992).

The constructivist classroom often gives students the opportunity to promote their own learning goals and to generate their own learning and assessment activities. Inquiry is the cornerstone of that classroom and students are taught and the teachers model true inquiry both in the lab and in the classroom. Inquiry teaching methods have been found to

be highly effective in promoting better attitudes toward science, improving language skills, logic, science process skills and the mastery of science content (Basista & Mathews, 2002). In the middle school classroom inquiry, teaching methods have been found to enhance generally student performance. Inquiry as a teaching strategy begins and ends with the interests, wonders, and curiosities of the students and allows the student to make meaning of the experiences as they explore and explain the data. Inquiry with authentic questions generated from student experiences is the central strategy for teaching science and is the preferred method of instruction with the teaching and professional development sections of the National Science Education Standards (NRC, 1996). Learning through inquiry empowers students with the skills and knowledge to become independent, lifelong learners while finding solutions to their own questions will allow students to gain an appreciation for the discovery process (Llewellyn, 2002).

The constructivist teachers promotes the tentative nature of science and underscores the notion that science is “theory laden and socially and culturally constructed” (Taylor, Dawson, & Fraser, 1995). The constructivist learning model begins with an active and somewhat engaging process that provides an opportunity for the student to create meaning from the experience. Students come to school with their own rich and varied experiences that allow them to interpret the experience based on their own mental models. As they struggle to link new ideas and new information to prior knowledge, they may choose to assimilate this new information or discard it or make accommodations depending on their ability to make the conceptual change. Posner, Strike, Hewson, and Gertzog (1982) present the idea of conceptual change based on student dissatisfaction with a new concept which does not fit into their conceptual model.

Once dissatisfaction occurs, students will replace it with a concept that they find intelligible (I can understand it), plausible (this makes sense to me), and it is fruitful (it will be useful to me in a variety of new situations). This allows students to replace misconceptions with more accurate scientific knowledge (Posner et al.). Misconceptions grow from student observations, media, and daily experiences (Llewellyn, 2002). This reinforces the work of Piaget (1977) and his theory on how children construct their own understanding.

Piaget (1977) saw the student as a scientist who is always comparing new information with previous knowledge. According to Piaget, the process of adaptation occurs through assimilation and accommodation. Assimilation takes news knowledge and fits it into the child's existing mental models. Accommodation involves the complete restructuring of mental models in order to integrate the new learning. Adaptation occurs when new information that does not align with their presently held beliefs. Assimilation and accommodation happen at the same time for students in most cases. The student is self-regulating his own learning by trying to maintain his own equilibrium or balance of the integration of new and old information into the mental models held by the student. Disequilibrium occurs when a student experiences new knowledge that does not fit into the student's schema; Piaget called this cognitive conflict. When a student is presented with information that does not fit into his schema, that student discards it, assimilates it or accommodates it in order to make it personally meaningful (Piaget, 1977).

Teachers must teach to misconceptions in the constructivist classroom so that students may have a clear understanding of scientific concepts unclouded by inaccurate or naïve information. One way to uncover misconceptions in the science classroom is by

using the Learning Cycle (Karplus & Thier, 1967), which is based on the work of Piaget. This teaching strategy involves a five-step sequence of learning activities that invites the student to learn from being actively involved (Karplus & Thier). The first step is engagement. The teacher structures a modeling of content, questions, discrepant event or similar interesting activity that gains (or hooks) the student's attention, activates his or her learning, and involves him or her in the curiosity of the subject matter. This also allows the teacher to assess prior knowledge, allows the student to share previous experiences about the topic, and, perhaps, allows identification of any misconceptions held by the student. The next step is an exploration of scientific concept where the student is required to become involved in the discovery of data and their refinement. The students are actively using scientific processes and equipment during this state and opportunity for the student to raise questions, refine his or her hypothesis, and become cognitively engaged in the studying of the phenomena are provided. The third step involves the explanation of the phenomena both from the students and the teacher. This is the portion of the lesson where the teacher models the appropriate scientific vocabulary for phenomena and helps the students articulate their findings. The fourth step involves the extension of the concept. How can this information be applied to other scientific concepts? Where are the real world concepts where this phenomena applies? Finally, evaluation puts closure to the sequence. This portion of the lesson allows both students and teacher to assess the level of learning, make connections between and among scientific concepts, and summarize the new learning (Llewellyn, 2002).

Another learning cycle, called the inquiry cycle, follows the same pattern of activity and promotes active engagement in the learning of the students. In this example

of exploration, students first are involved in *Inquisition,* where the students states their own questions or wonders. Then the students are involved in *Acquisition*, where they state possible solutions or answers to their questions and wonders. The third step involves a statement to test (what some might call a hypothesis). This step might be referred to as the *Supposition*. The fourth step involves *Implementation,* designing and carrying out a plan. The fifth step is the Summation where students collect evidence and draw conclusions. The final step of this plan is *Exhibition*, where students share and communicate results (Llewellyn, 2002).

Another model for scientific inquiry, called the Constructivist Learning Model, involves four steps: Invitation, Exploration, Explanation, and Take Action. Invitation begins with engaging the student in the learning event with an invitation to learn. The teacher establishes a context for learning by asking a question, modeling a discrepant event or assessing background knowledge. Exploration involves structuring activities that enable students to test their predictions, engage in observations, collect data and describe and interpret the data. Explanation involves the students' articulating their newly constructed views on the studied phenomenon. Take Action involves the teacher's and the students' applying knowledge, sharing information, asking questions, making decisions, and producing evidence of learning. During all four of these steps, the students may work in small groups or with partners, but they always assemble at some time with the whole group and with the teacher so that new knowledge becomes public and is published (Yager, 1991).

Another model for inquiry learning is the Generative Learning Model by Mark Cosgrove and Roger Osborne (Llewellyn, 2002). This model also involves four

phases: Preliminary, Focus, Challenge, and Application. The Preliminary phase involves the teacher's assessing prior knowledge and experiences of the students. The Focus phase involves the teacher's providing motivating experiences, asking questions, and allowing students to clarify their knowledge of the topic. The Challenge phase involves students presenting their mental models, schemas, and understandings of the topic and comparing their conceptions with those of the scientific community. Finally, the Application phase involves students' using their new knowledge to solve problems, make applications and clarify the studied concepts.

There are obviously many models of inquiry, but they all have several components in common:

1. There is always the honoring of the prior knowledge and experiences that students bring to the activity.
2. There is always a question or problem to be solved
3. They all involve choosing a course of action and carrying out the procedures
4. They all involve gathering, recording, and interpreting data
5. They all involve publication of the data so that others can review

Using a constructivist methodology for the teaching of science content allows the teacher to structure activities that allow students to have meaningful interactions with scientific information. By a purposeful and intentional use of inquiry, the teacher moves the learning from teacher-centered, teacher-driven to student-directed, student-initiated. Constructing meaningful knowledge becomes the central theme of the science classroom.

Summary

For this research, teacher preparation is at the core of understanding the novice teacher’s perception of how their coursework influences their teaching. Principles of excellent teacher preparation will allow novice science teachers to be well prepared for transforming their scientific knowledge into meaningful instruction for their students. Confidence levels of novice teachers influence their ability to provide meaningful experiences for their students. Analyzing principles of pedagogical content knowledge and constructivist epistemology will help to understand the thinking and perceptions of novice teachers. This understanding provided a basis for analyzing how NSCI 3001, NSCI 3002, and NSCI 3003 supported the teacher preparation of these three teachers who were new to teaching science for the 2006-2007 school year.

CHAPTER 3

METHODOLOGY

Introduction

The purpose of this chapter is to describe the methodology used to investigate the thinking of three novice-year teachers concerning a series of science courses called NSCI 3001, NSCI 3002, and NSCI 3003. The courses were completed during their pre-service teacher education program in middle grades science at a major university in the southeastern United States. The study was guided by the following question: How do former NSCI participants who are currently novice teachers describe their confidence in their ability to teach science content to their middle school students?

The framework for this investigation was a qualitative study. This qualitative approach is often called the emerging paradigm (Lincoln & Guba, 1985) as opposed to a quantitative study which Lincoln and Guba term the positivist paradigm. I used an ethnographic tool called a case study. A case study is a detailed examination of one setting or perhaps a single subject, a single depository, or a particular event (Merriam, 1988). Case studies are generally best represented as a funnel: The study starts with general questions, and the collected data, reviewing of the data, and interpretation of the data inform the best way to proceed (Bogdan & Biklen, 1992).

In this research, the case study was the series of courses referred to as the NSCI science series. The intent of this study was to learn about some particular phenomenon of interest, which in this case is the descriptions of three participants (Maykut &

Morehouse, 1994) as it relates to their participation in the NSCI series and their confidence to teach middle school science content. The participants were teachers who were novice science teachers during the 2006-2007 school year. I hoped that the data would provide insight into the level of influence the NSCI series of courses made on the informants' confidence in their ability to teach science content.

Overview

Four purposes for conducting a qualitative study are to explore, explain, describe or predict (Marshall & Rossman, 1995). This study was a descriptive study. It was neither intended to explain nor to predict future behavior; its intent was merely to record the descriptions of novice teachers and their reflections upon a specific pre-service science series of courses as it related to their confidence to teach middle school science. This data was intended to tell what is happening, what the researcher thinks is happening, and perhaps why it is happening (Maxwell, 1996). For this research, there was no hypothesis or theory being "proved" or tested; instead, the theory emerged as the data was collected and analyzed. The underlying epistemology of this research was constructivism. Constructivism as an epistemology, or a way of knowing, indicates that meaning is constructed and mediated by the learner or the participant based on prior experiences. As the stories were told and the data was coded and analyzed, I constructed meaning from the input of the key informants or participants. The informants, as they described and analyzed their perceptions of the coursework, constructed their own meanings from their remembered experiences. As the participants and I constructed meaning from the data, both the emic and etic viewpoints were presented. Emic views are those indicated by the key informants or participants. It involves their descriptions and actions based on their

understanding of the events. The etic viewpoint is that of the researcher and his or her explanations and interpretations of the events as presented by the participants (McMillan & Schumacher, 2001). These two viewpoints when combined and used honestly and accurately provide a picture of the data that is panoramic and multidimensional.

Selection of Participants

The participants in this study were members of a cohort who took a series of three science courses required for middle school science pre-service teachers. The intent was to choose three to six participants for this study. The participants were purposefully chosen from the population of all students in the middle grade teacher preparation program who took all three of the science courses in the NSCI 3001, NSCI 3002, and NSCI 3003 series. This was an important criterion for the participants because they would have had the experience of being taught by three instructors with three different content areas and styles of teaching.

Another criterion for selection of the candidates was that they were novice teachers in their first 3 years of teaching experience during the 2006-2007 school year. The intent of this research was to study the influence the series of courses had on the teachers' descriptions of their confidence to teach science content during their first 3 years of teaching.

From the population of teachers who took all three courses and then were novice teachers, the final criterion for selection was that they were willing and able to participate in the study. An email invitation (Appendix A) to participate was sent to the population of all novice teachers who were former participants in the NSCI series and were novice

teachers for the 2006-2007 school year. Three responded and agreed to be a part of the study. Participants are identified by pseudonyms in this report.

Participants

Jack is a 34-year-old White man who teaches earth science in a large metropolitan school district. He came to teaching after being involved in another career. He and his family chose for him to make a career switch and made some sacrifices that allowed him to become certified in middle grades. Jack originally wanted to teach social studies, but he was hired as a science teacher. His school is a mixture of upper and lower middle class, changing demographics and is challenged to meet the standards set by the school district to make annual yearly progress. Jack found this to be a personal challenge and indicated that he works hard to meet the needs of his students.

Ewen is a 42-year-old White man who teaches earth science in the same large metropolitan school district as Jack. Science was his first love during his certification coursework. He chose his particular school because it did not meet the benchmarks for the state and was considered an “NI” school. Needs improvement schools are those that do not meet annual yearly progress as defined by the state Department of Education. He wanted to teach in a school where he felt he could make a difference.

Amy, a 42-year-old White woman, teaches earth science in a middle school in a large metropolitan district that is near to Jack and Ewen’s district. Her school is fairly affluent, but it is challenged by having many different languages spoken. Amy’s first choice was to teach science, and she chose her school because of the diversity that was present in the school population.

Data Sources

Using a variety of data collection methods increases the confidence of the research findings. Data from different sources can be used to corroborate, elaborate or illuminate the research question (Marshall & Rossman, 1995). Data for this study were collected from interviews, a jot-list assignment, and a focus group discussion. Having multiple data sets allowed for triangulation of the data.

Phase I, the solicitation to become a member of the study, was accomplished by my contacting each member of a pool who took all three NSCI courses, who was a novice teacher during the 2006-2007 school year, and who was willing to be part of the research study. After the contact had been made and the participant indicated his or her willingness to participate, within a week each of the selected participants was scheduled for an individual semi-structured interview (Appendix C) in Phase II of the research.

Interviews, such as the ones used for this project, are purposeful conversations used to gather descriptive data in the participants' own words that will allow the researcher to develop insights on how the participants' interpret some piece of the world (Bogdan & Biklen, 1998). The interviews were audiotaped and transcribed to provide accurate analysis of information. An interview protocol for recording information during the interview was used. The protocol involved a prepared opening statement to each key informant and then continued with the interview questions. The interview questions used for the one-on-one interview included:

1. What is your definition of confidence?
2. What do you consider to be confident practices in the classroom?

3. What pre-service or service activities, if any, have had the most influence over your science teacher practice?
4. Were there any events during your pre-service preparation that either greatly promoted your confidence to teach science or diminished your confidence to teach science?
5. Tell me about your NSCI experiences. (Optional to be used if the participant did not refer to their NSCI experience.)

Probes were provided to solicit expansion of previous responses. Space was provided on the interview protocol for both responses of the key informants and for my reflective notes (Creswell, 2003).

Each participant was asked to reflect on their teaching for 2 weeks. They were asked to record any activities, experiences, assignments, etc. that were influenced by their participation in the NSCI integrated science series. This was called the jot-list assignment.

Phase III, a focus group, was conducted and was held at a neutral site to promote further conversations about the NSCI courses. This method of data collection assumes that the participants' opinions do not always form individually. People often need to listen to others' opinions and understandings in order to form their own (Marshall & Rossman, 1995). The focus group was informal and was guided by information provided during the interview phase. Two questions were used initially to guide the discussion (Appendix D). The two questions for the focus group were:

1. What pre-service/service experiences do you think best promotes teacher confidence?

2. What experiences, if any, would you like to have had as a pre-service teacher that would have promoted your confidence in your ability to teach science content to your middle school students?

The focus group was audio taped and transcribed and a focus group protocol similar to the interview protocol was used. Phase IV was the member checking phase.

Data collection took place over a 6-week period. Teachers from the pool of former NSCI series of classes were solicited for the study. Each teacher who volunteered for the study was interviewed during Phase II at his or her respective school. Phase III, the focus group, was scheduled after the data from the interview were coded and analyzed. Phase IV, member checking, allowed the participants to clarify their thoughts and be sure that my etic perspective did not interfere or misspeak their emic positions. Member checking provided for trustworthiness of the data.

To reduce the risk of bias on my part, I used a peer debriefer, a colleague who examined the data both with me and independently after each phase and asked pertinent and probing questions that allowed the story of these participants to be told in an honest, direct manner. The peer debriefer was asked to code the transcriptions independently from my coding to see if there was alignment of affirmations and themes. The peer debriefer provided another measure of reliability and trustworthiness to the study and kept the research “honest.”

Timeline of Data Collection

A timeline of the data collection activities is presented in Table 2.

Table 2

Summary of Research Phases

Phase	Location	Participant Time	Data Source	Data Managed	Analyzed	Timeline
Phase I		2minutes	Explanation of project and solicitation of interest	Spreadsheet with contact information	21 data sources contacted; 3 responded	One week
Phase II	Neutral site	One hour	Individual interview: Questions outlined in Appendix Jotlist assignment provided	Audio recorded and transcribed; transcription color coded, visually displayed on charts around data area "visual wallpaper"	Themes affirmations coded and categorized using matrix; unique responses noted	Two weeks
Phase III	Neutral site	Two hours	Focus Group: Questions outlined in Appendix	Audio recorded and transcribed; transcription color coded, visually displayed on charts around data area "visual wallpaper"	Themes affirmations coded and categorized using matrix; unique responses noted	Two weeks
Interim	Data area		Data will be debriefed with researcher by peer	Peer debriefer will provide input to researcher about data	Bias, if present, will be identified. Confirmation by peer debriefer of themes and affirmations will be sought	Ongoing
Phase IV	Electronic	Will vary by participant	Each participant sent analyzed data for member checking	Member checking compared to written analysis	Adjustments made as necessary	Two weeks

Analysis of Data

The data from each interview and focus group were audio taped and transcribed after each research event. The data were analyzed by an inductive approach. The data were not grouped together according to predetermined categories. The data themselves determined the direction of the study as is typical of qualitative research (Maykut &

Morehouse, 1994). A constant comparative method was used to analyze the data and the visual wallpaper approach was used to code and organize the data.

Glaser in Bogdan and Biklen (1995) describes several steps in the constant comparative method of analyzing data:

1. Begin collecting data.
2. Look for key issues, recurrent events, or activities in the data that become categories of focus.
3. Collect data that provide many incidents of the categories of focus with an eye to seeing the diversity of the dimensions under the categories.
4. Write about the categories you are exploring, attempting to describe and account for all the incidents you have in your data while continually searching for new incidents.
5. Work with the data and emerging model to discover basic social processes and relationships.
6. Engage in sampling, coding, and writing as the analysis focuses on the core categories.

Visual wallpaper is a process of taping large pieces of paper around a research room and beginning an inductive process of coding and chunking material. Lincoln and Guba (1985) refer to the process of identifying the chunks or units of meaning as *unitizing the data*. As each piece of data is coded and identified, it is cut from the transcription of the interview and focus group and taped with like emerging themes. Pieces of data were viewed and reviewed, taped and untaped, categorized and re-

categorized until themes emerged that seemed sensible. A matrix was used to identify common themes among the participants' responses (Glesne & Peshkin, 1992).

A research notebook was kept throughout the entire research process. The research notebook included a research log, field notes, and transcriptions. Bogdan and Biklen (1992) indicate that a research log contains any information that is important to the progression of the study. It contained accurate records of mailings, emails, phone conversations, interviews, and any other information concerning contact with participants. Field notes provided data about the setting of each interview and the focus group. Body language, gestures, and expressions used in conjunction with the audio taped events provided extra information about the interview and focus group. I took notes quickly during the interview and focus group and wrote up the transcriptions immediately and merged the transcription and field notes so that accuracy could be maintained as memory failed.

Trustworthiness of the Data

Lincoln and Guba (1985) suggest four constructs that represent the qualitative paradigm: credibility, transferability, dependability and confirmability. Credibility of the research event refers to the manner in which the research was conducted. Was the research conducted in a way that accurately identified and described? Although it is difficult to capture what is really happening in any interaction as an observer, it is important that the data are accurate and well organized. For this research, triangulation of data was used as one method to promote credibility.

Triangulation involves using multiple data collection resources (Lincoln & Guba, 1985). The thinking of the participants was examined though interviews, a jot-list

assignment, and a focus group. This allowed for corroboration of the data and provided for a more complete picture of the descriptions of the teachers. Member checking was used to allow the participants to review the results of the interviews and the focus group to assure that the analysis and description of the data was accurate and a true reflection of the participants' input. Allowing the participants to elaborate, review, and extend information also contributed to the credibility of the data and its analysis (Maykut & Morehouse, 1994). A peer debriefer was used to review and ask questions about the research (Creswell, 2003). Using a peer debriefer allowed for an outside person to walk through the data and eliminate potential bias. This person in actuality played the devil's advocate and kept the researcher "honest" (Lincoln & Guba, 1985).

Transferability or generalizability refers to the ability to apply the findings from the research event to another context. This was a bounded case study and was not meant to be transferable or generalizable. The "thick, rich" description may allow others, however, to draw parallels to similar studies (Creswell, 2003).

Dependability refers to the ability of the researcher to account for any changes in the design of the study or other phenomenon that may present itself throughout the study. It also refers to consistency of the results of the data with the data that is collected (Merriam, 1998). Dependability of the information for this research study was promoted through maintaining organized records that are transparent and easily accessible through an audit trail of the log book completed during this research.

Finally, confirmability attends to the issue of the research event providing a wide variety of evidence that confirms the findings of the researcher and would allow another to think through the process and perhaps arrive at the same findings. Triangulation of the

data sources and a peer debriefer promoted confirmability. The data from the interviews, jot-list assignment and focus groups were organized so that a clear record of all transactions was transparent to all. Audio taping and transcribing of the interviews and the focus group as well as member checking promoted confirmability of the data. For this study credibility, dependability and confirmability were issues that had to be addressed; generalizability is not a construct that was given attention because I did not intend to consider this information to be generalizable to any other context.

Human as Instrument

The human instrument was the primary tool for gathering data in this study. Because I was the researcher, I knew I must be transparent about my perspective and my position in the research. These participants, along with others in the NSCI series, were involved in two pilot studies, which I facilitated, and, therefore, they knew of my interest in this particular series of science courses.

As a former classmate and peer researcher, I recognized, however, that I did not come to this research without biases and assumptions. It was my task as the researcher to admit my bias.

I found the NSCI series to be influential in my increased confidence to teach science content. Because of this, I had to make every effort to remain objective and not indicate to the participants my perceptions of the course. I also came to this research with the assumption that these participants would be reflective about their experiences, honest about their perceptions and that they would have the ability to speak openly, honestly and completely about their ability to teach science content during their first years of teaching.

My use of triangulation, member checking, and a peer debriefer promoted an honest and accurate picture of the perceptions of these participants.

Summary

This chapter provided a description of how this study was designed. A case study design was chosen because I considered this series of courses with this group of teachers to be a bounded study. I chose a qualitative study because there is not a hypothesis to be tested or a preconceived theory about the research; I wanted to tell the story of these participants' experience and record their descriptions of their confidence in their ability to teach science content as novice teachers. I chose the constant comparative method of data analysis because it allowed me to discover themes or assertions that emerged from the data and allowed the participants to guide the study. I was comfortable with this degree of ambiguity. The use of interviews, a jot-list assignment, and a focus group provided for triangulation and member checking and peer debriefing reduced the risk of bias in the study.

CHAPTER 4

RESULTS

Introduction

The purpose of this chapter is to present the outcomes and synthesis of the responses of three participants in this research study. The problem being studied in this research is the relationship between a specific series of integrated science courses (NSCI) in a science teacher preparation program and the actual needs of the science teacher during the first years of teaching practice. The intent of this study was to record the thoughts of three novice teachers who completed all three courses in the integrated science series as it related to their confidence to teach middle grades science content. Twenty-one former participants in the class were contacted and invited to be a part of this study. Three participants responded positively. Jack, Ewen, and Amy were all novice teachers during the 2006-2007 school year and had completed all three courses. This satisfied the criteria for selection for this study.

Responses

Jack

Jack reported that confidence meant you are sure of yourself. “You know what you are doing; you are prepared and you know what you are talking about”(I). He reported that he was always one step ahead of his students because he prepared thoroughly. Knowing what the students will ask and what misconceptions they hold allowed him to be ready for anything. He used the example of teaching rocks with his

students this year. Jack stated that he had a good background to teach science because of the depth of study in the earth science parts of NSCI coursework, but he also reported that in order to be confident as a teacher he had to revisit the concepts to be taught. He had to review the material ahead of teaching it so that he could teach with confidence. Even after teaching for a year, there were still some areas he reviewed before teaching them, such as mass and weight.

> I just need to get it in my head. Am I a confident teacher? I am getting there. I am working hard. I know my content well and most would consider me a confident and a good teacher. On a scale of one to ten, I would consider myself to be an eight. Last year I was a six. I know I had good training in my science courses (NSCI specifically), but experience allows me to do better each time I teach a concept. (I)

Jack reported that he had not been a confident student and that, because he had moved around a good deal, he did not take school seriously. However,

> because I started teaching late and was taking classes as an older student, I took my science classes very seriously. Not all the kids in my NSCI classes did, but I knew when I started teaching that I would have to know all of the content in order to be able to teach confidently. Some of the younger students were not prepared to work hard or to do what they needed to do to be well prepared teachers. (I)

Jack reported that confident teachers use a variety of strategies to involve their students in the work including KWL (What you know, what you want to know, what you have learned) charts, ticket out the door (a strategy for review and synthesis), scaffolding, building on what they know, activating prior knowledge, using lots of graphic organizers, manipulatives, and anything else that allowed students to be engaged in the learning. "Science is not reading the book and answering questions. That is what teachers do who are not confident and do not know their content. Science is playing around with the ideas, using inquiry and hands-on" (I). Confident teachers also ask many questions and allow their students to ask questions. "My goal as a confident teacher is to turn the questions

back on the students so they learn the material well. I make them look up the answers and report back to the class" (I). He reported that if one student asks a question, then there are probably six other who have the same question.

Jack reported that his work at the university has promoted his confidence in his ability to teach middle school science. He continued,

> When I think of the NSCI integrated series, I just remember all the ways they taught with hands-on. I remember the slinky activity in physics. That is something I do with my middle school students. I loved the swabbing all over the place in biology and finding and growing bacteria and then finding out which antibacterial products that didn't allow it to grow. It was cool to know which common products were helpful and which ones weren't. This is the kind of science teachers use when they do not just go through the book; when they are confident enough to get out of the teacher's manual and really teach science to students. (I)

When thinking of the physical science class, Jack reported that Dr. P would use the vocabulary while teaching the concept.

> I think of momentum and acceleration. He (Dr. P) used ramps and cars and taught momentum and acceleration and used the terms while we were doing the activity. This taught me not to have my kids look up words in the glossary, but to have them use the words while we are learning the concepts. (I)

Jack remarked that the biology course allowed him to see how PowerPoint and lab activities could be integrated. He emphasized the importance of integrating the academic content with the activities to produce confident students.

> I use a density lab that allows my students to use candy bars to learn the concepts. Using home stuff and stuff the kids have in their lives makes the concepts more meaningful. Of course, we then eat it. This kind of instruction influenced my teaching. Confident teachers just do not have their kids read about science; they do science. I have to have my kids using thermometers and rulers (something they do not always know when they get to my class) because they need hands-on experiences. (I)

The geology course was very hands-on and a good mixture of content and activities, according to Jack. He especially mentioned the tributaries activity where they

sprayed dirt and saw the rivers and tributaries form as one that influenced his teaching. The portfolio activities influenced his teaching and allowed him to understand the importance of rubrics. “It was made clear to us how our projects would be graded; this was the first time I really had seen rubrics used well”(I). He also noted that the integrated science fair allowed him to see how a science fair would be organized and the kinds of ways that the instructor could help students improve their projects.

> I really loved the integrated science fair project. I got a lot out of it both from the project itself, but also from the process. It made me think like a real scientist thinks and the feedback, again, challenged me to think it through. This added to my confidence as a student and later as at teacher. (I)

Jack reported that the courses that he took at the university allowed him to teach with a different perspective. He emphasized his use of inquiry and how important it was to make his students think deeply about science. “I want to continue to have my students do many inquiry labs. It makes them think seriously about science and how it relates to their world” (I).

Having the science courses that allowed him to see science being taught to him in the same way he was to teach it to his students promoted his confidence to teach science to his students. He indicated that exposure to teaching methods was the number one reason he is a confident teacher. He listed using carousel brainstorming, K/W/L charts, the jigsaw (a cooperative learning activity), concept mapping, brainstorming, lecture combined with demonstrations and authentic projects as strategies he uses with his students (JL). “By going through these activities in NSCI I was able to see how to teach it while I was learning the content. I keep going back to exposure as the one defining reason I am confident to teach science” (FG).

Jack indicated that his student teaching experience was also something that really promoted his teaching confidence. Being able to work under a teacher who knew what he or she was doing was a good experience.

Jack indicated that his learning style was considered in the NSCI series. He felt there was something for everyone so no matter what learning style you had, you could learn the material.

> There was something for every learning style. I learn best by doing the work; I have to do it to learn it. Hands-on and problem solving worked well for me. There were activities for everyone. I think it was the United Nations of Learning Styles in NSCI. Whatever way or modality we learned best, we had it. (FG)

Although Jack did not recognize it at the time, he realized later that the science instructors were teaching him how to teach by teaching him the science. He noted that the feedback from the instructors was instrumental in his learning the science content as well as how to do that with his own students.

> Something else they did that I do with my students is talk to them one on one about the concepts of science. Dr. E was the hardest; she made us work hard and made us the think the most, but she was always available to talk about the subject both during class and after class. (FG)

He also indicated that Dr. P would sometimes debrief after specific activities and tell the class why he had taught it a specific way. Jack indicated that he sometimes thought the activities in science class were “lame” and he wondered why they, as college students, were doing activities like moving around the room pretending they were the moon and the sun and the earth. “I realized later what a great activity it was because it taught us the difference between revolution and rotation in a very physical way”(FG). Having the debriefing by the instructors allowed Jack to make the connections from the coursework and his own future classrooms of students.

Jack indicated that the projects that he had to complete with the guidance of the rubrics were powerful experiences. The use of the scrapbook, the authentic science fair project, and the burning question activities allowed him to learn the subject matter to a deeper degree than if he had just read the book and answered the questions and then took a test. Labs, however, were Jack's favorite way of learning.

> I never wanted to miss lab. I loved doing the labs and the hands on. I keep coming back to the erosion lab and the cookie lab in geology. They were great fun and I loved working in my groups and I loved learning the content in a hands-on way. I loved the cigar box lab and the forensic labs. We learned about crime sciences, hair and fingerprint analysis. It made me want to teach that way to my students. (FG)

Having exposure to many strategies and activities promoted Jack's confidence to teach middle school science. "The NSCI courses directly allowed me to be a confident science teacher. I really wanted to teach social studies, but the job I was hired for was science. I was nervous at first, but now I am considered the 'Bill Nye, the science guy' of my grade level" (FG). He reported that teachers in his school come to him for help with their own classrooms. "Confident teachers want to share their ideas with others. They want other teachers to use their ideas and they want to get ideas from others" (FG).

Jack stated that the best way for teachers to "learn science is by doing science." He concluded that the best preparation during pre-service was to see science being taught by instructors who understood their subject matter, knew how to teach it, and understood how it must be taught to students as well. "The instructors for NSCI were perfect for the job. They understood science; they understood college students and pre-service teachers and they had a clear understanding of how middle school learners learn. How can you beat that?" (FG)

Jack summarized by stating that his experience with NSCI had provided him with all of the skills and tools necessary to teach middle school science. When asked if there was anything else he would have like to have done, he mentioned two things. “I wish we could have seen middle schoolers in labs where the lecture was integrated like it was in NSCI, and I wish we could have ridden the BioBus with Dr. B” (FG).

Ewen

Ewen’s definition of confidence:

> I have no worries or nervousness about my teaching. I know my content and I know the AKS (Academic Knowledge and Standards outlined by his school system) and how to put that all together. I was well prepared in the NSCI series to teach the science content as well as how to teach it and I feel very confident that I know my information so well that I can teach it well to my students. I was well prepared at GSU with my coursework and with my student teaching; I really think I was almost 100% ready to teach my science content with confidence. (I)

Ewen stated that he felt that his confidence was built on the fact that he was well prepared and that he probably learned more science content than he has time to teach. “Our curriculum is still 100 miles wide and an inch deep” (I). Ewen reported that it was more than the classes, however, that made him confident:

> I had to put work into it; I had to take my education seriously. I think because I was an older student I had a different perspective on what was happening. It all boils back to what you are in school for. For me it was to get an education to become a teacher. I had a desire to teach, not just to have a job so I think I worked harder to learn the material and get my A’s than other students may have. (I)

Ewen reported he wanted to make a difference in the lives of his students and so he worked hard as a teacher just as he worked hard as a student.

Ewen believed that confident teachers use a variety of strategies. “They change it up. Things are different every day so that kids won’t get bored. As a confident teacher, I know lots of ways to teach the content to my students.” One strategy that Ewen described

as a confident practice was EATS. “E” stands for Essential question. “You will see that my essential question for both math and science are on the board. This makes sure that both the students and I stay on task.” “A” stands for activating prior knowledge. He reported that all good teachers do this. He described using a KWL chart or using the hot dog (folding the paper lengthwise) and asking kids to write down what they know on one side and at the end of the lesson, they write down what they know now. “They see that an hour before they didn’t know much at all and now they know a lot.” He used concept maps and Venn diagrams to keep the flow of the lesson going. “As a confident teacher I know lots of ways to keep the kids engaged so they do not get bored while teaching them the content.” The “T” stands for the teaching part. This is where Ewen said he really “changes it up.” He used a variety of teaching strategies and chose them based on what worked for a particular concept. He particularly made use of inquiry labs and demonstrations and hands-on activities.

> Confident teachers use lots of hands on. I try to have the kids to be involved in realistic, real life activities that they can understand makes them get the content better. Confident teachers use what works with their students; they use what works to promote confidence in their students. So a confident teacher makes confident kids and confident teachers and kids do a better job of improving student achievement. (I)

Finally, the “S” in EATS stands for summarize. “This is where the students tell me what they have learned or it might be an assessment. I use formal and informal assessment methods . . . again, mixing it up” (I).

Ewen noted that his favorite strategies that he used from NSCI with his students include burning questions, inquiry labs, jigsaw, carousel brainstorming, and small group work (JL). He believed that this variety of strategies allowed him to meet the needs of all of his students just as he believed that they made a difference in the NSCI series.

Ewen reported that a confident teacher was a "total professional." They knew their material, the goals and objectives for their units, and their lessons. The kids saw that they are prepared and are engaged in the lesson more because the teacher was prepared. Another thing that shows a teacher is confident is their willingness to share with others.

> As a confident teacher I want to share what I know; I feel like I am a member of a cohort or a team and I want to ensure that all members of my science team are doing he right things in their classrooms. Confident teachers in the team meetings bring up good ideas and share with one another; those who are not confident do not speak up. Confident teachers want to have every teacher on their team meet the standard of good teaching. (I)

Ewen reported that his coursework and student teaching experience at the university contributed in many ways to his confidence as a teacher. When thinking about the physical science portion of NSCI, Ewen reported that he:

> . . . really responded to Dr. P's confidence. He knew his topic and he knew how to teach it to his students. He was probably the biggest influence on my teaching. He had plenty of hands-on, especially if you stayed after class! His homespun ways and humor really caught my attention. I use lots of humor in my class. His teaching of vocabulary was very practical and really made me get the stuff he was teaching. I probably admire Dr. P the most because I was looking for a male role model . . . someone to model my teaching after and he was it! (I)

When thinking about the earth science portion of NSCI, Ewen reported that he loved Dr. E's joy of the subject matter. "Dr. E loved her subject, had a passion for it, and it showed in her instruction. Her passion was infectious; that is what I want to use as a model for my students" (I).

When considering the biology portion of NSCI, Ewen reported that his learning style did not jibe with Dr. L's teaching style. He did not enjoy the PowerPoints and was often bored. He attributed this to the difference in learning style and teaching style or it could have been because he had a strong background in the subject matter already.

“Although there were many hands-on activities, they were just not as engaging as the other NSCI classes for me” (I).

Although Dr. I was not one of the NSCI instructors, Ewen commented that he learned a variety of teaching strategies in her class, especially in the area of inquiry.

> I learned a lot about the inquiry cycle and methods and strategies about teaching science. This gave me a good background in both the subject matter and the way to teach everything. All in all, all of the instructors were down to earth, real life, used the vocabulary and humor to teach science concepts. My experience with NSCI was valuable and made me a confident teacher. (I)

Ewen reported that his school system provided excellent in-service opportunities that allowed him to be involved in many engaging activities with his students in his science class. He stated that his work with the Max Thompson Learning Focused Schools has had a tremendous influence on his teaching. He suggested that his foundation in NSCI has allowed him to more effectively use what he is learning now (in the Learning Focused Schools workshops) in his classroom.

Ewen reported that he chose to teach 8th grade earth science and that he chose the school he was in because they were having trouble and were an Needs Improvement school.

> My student teaching experience which was wonderful and the coursework that I participated in at [the university] prepared me well to teach middle grade science. I know that it was the classes and information that was provided in my pre-service program that allows me to be confident. I do not have to worry about not knowing my subject matter or how to teach it; I learned all of that from the instructors in the NSCI series and the other teachers like Dr. W and Dr. I. They are my role models for teaching good science to my students. (I)

Ewen reported that he learned to teach the content by watching the instructors and used many examples in his own practice from the NSCI series. It was important for Ewen not only to hear about the science and have someone tell him how to teach but also to see

the instructors using the strategies with the college student that he would be using with his own middle school students. “You saw in my classroom that I have many of the projects we used in class. I use all that stuff with my students” (FG). Ewen indicated that it is the use of projects in his classroom that contributed to his students feeling successful. By seeing how the instructors in NSCI organized the projects and provided the rubrics, he was able to get the big picture of how it should work in his classroom. “I never knew much about rubrics until I saw how they were used in NSCI classes. I can use them with my students because I saw them from the student perspective” (FG). He contended that his students learned the science better, to a deeper level, because they were involved in authentic student projects. His use of projects allowed him to teach the curriculum in a more thorough way and allowed his students to use process skills while they were learning the content.

When asked what experiences promote teacher confidence the most during pre-service, he responded that it was having the teacher who worked well with pre-service teachers that really mattered. He stated that being able to see the instructor use the same activities that he will be using in his classroom helped him anticipate what he would be doing with his students.

> Seeing Dr. P, Dr. L, and Dr. E actually using the strategies that I would be using in my classroom prepared me for student teaching and then for my own classroom. I was well prepared to handle whatever came my way as far as content and teaching it to my students. (FG)

Ewen stated that there was nothing that could have been added to the program except more time spent on each topic in science during the NSCI series and more classroom experience. “I learned lots of content, but still need more to stay ahead of my students.”(FG)

Amy

Amy's definition of confidence:

> Confidence is knowing your content so that you can teach it easily. Those with no confidence are not comfortable. Confident means you know what you are talking about and knowing more than you are required to know. You anticipate questions from students. Confidence means that you are not afraid to try something new or go beyond the book. (I)

Amy reported that she was very confident in her classroom because she knew her subject matter and she knew how to teach it. Being organized was a hallmark of a confident teacher. She understood the importance of anticipating what questions the students might ask and the importance of knowing the misconceptions that her students would have about the science content. "Misconceptions are a big issue with me. Without having been well prepared to teach science during the NSCI integrated series and other courses I took at [the university], I might have been teaching to those same misconceptions" (I). Confident teachers, according to Amy, produce confident students. "Confident teachers have students who know what's going on" (I). The students enjoy having science conversations and like being engaged in the lessons and not just reading the book. "Teachers who are not confident direct their students to do p. 5-9; they are really assignment givers and not teachers. They just want the kids busy so they can hide the fact that they do not know the science well enough to teach the kids" (I). Amy reported that she was very confident as a teacher. She felt that her second year of teaching was better than her first as it related to teaching science content and having confidence in her ability to teach. "I think experience plays a big part in being confident" (I). Confident teachers are not afraid to try new activities with their students.

> Because I am confident in my content, I am not afraid to try new strategies with my students and I think that confidence spills over onto them and they are able to try new stuff as well. An example of this was when we

> were doing a lab about sugar and one of the students asked if it would change things if we use salt in the water. Well, right away, I went and got out the salt and we tried it. (I)

Amy reported that confident teachers used discussion as a key tool for teaching science and, therefore, confident teachers organized their classrooms for dialogue and taught the appropriate science vocabulary through discussion.

> I have lots of discussion and dialogue and I want my students to be comfortable with the content just like I am. I do not want them to be afraid to talk about it. I think it all comes back to kids talking about science and using science vocabulary correctly. Sometimes I hear them continuing the discussion later because they are interested in it. I love it when my students talk science and use the correct terms and vocabulary for everything. They are talking like real scientists talk. (I)

Confident teachers, according to Amy, use higher-order thinking skills with their students and use questions that make them think. Allowing students to ask questions, also, made them think more deeply about the content. Teachers who were confident were not afraid to say they do not know the answer to something.

> I want my students to have questions and be able to ask questions of me and of the other kids and use the right terms. I want them not to be afraid to offer ideas and even if they have misconceptions or they do not know the answers or even if I didn't know the answers, that is okay. Confident teachers aren't afraid to say they do not know it. Teachers who aren't confident have some of the same misconceptions that students have and they do not know their science content. Teachers who aren't confident do not even want to touch on those subjects, because they know they do not know enough science content to teach it. (I)

Hands-on is a tool that confident teachers use. Inquiry-based labs, projects, and group work were also strategies to promote student achievement used by confident teachers, according to Amy,

> My concern is not keeping order in my classroom. I do not have the kids read the science text out loud so that the kids are quiet and in their seats. I want to use hands-on labs, and especially inquiry labs. Confident teachers use a lot of inquiry based labs; labs that can be turned upside down to

> change cookbook kinds of labs to inquiry labs where students have to think and hypothesize. (I)

Amy outlined many experiences that promoted her confidence in her teaching abilities. She mentioned her student teaching experience as having a great influence on her teaching and recognized that her coursework at the university provided the foundation for her student teaching. She noted that Dr. I's class on inquiry lab really promoted her ability to take regular labs and turn them into true inquiry. She also referred to Dr. W's class on weather as one that taught her about watching for teachable moments.

> We, of course, talked about Dr. W's trip to Antarctica. It was such a teachable moment. She modeled using something in her life to teach us with. I remember there were these incredible posters that we made and she encouraged scientific conversation based on that class. I do that with my students, too. (I)

When referring to the geology class, Amy indicated that the most overriding influence that the course had for her was the use of inferring and using evidence to draw conclusions.

> I just keep going to back to inferences as the one skill I learned from that course that I use with my students. Dr. E required a scrapbook about rocks for the class, and we had to do so much inferring. I just wasn't getting how it worked, but she patiently modeled the inferring process for me until I finally was able to do it. I use this kind of activity with my students now. I think this increased my confidence in my ability to infer and having my students do lots of inference type activities increases their confidence in their ability to infer as well. (I)

Amy reported that her participation in the physical science class had a great influence on her teaching. She considered Dr. P a very confident instructor who modeled excellent pedagogy, outstanding use of technology, and the integration of physical science with the other science disciplines. She considered the integration of science disciplines a major reason she was able to learn the science content so well and make connections among the concepts.

> One example I recall is the crystalline structures during the physics when it was also part of geology. Some schools still teach the subjects in discrete units so that there is biology by itself and chemistry by itself. I think teaching it like we had in NSCI helped me to make connections and I see that other schools are not using an integrated approach. Another example was reminding us of force and acceleration, which we learned in physical science, during astronomy. That helped me understand the concepts more deeply and now I can teach it to my students better. (I)

When thinking about the life science portion of NSCI, Amy reported that the PowerPoints were the most outstanding part of the course. They engaged her in the learning and the content and the pictures made the concepts clear. She reported that she used the PowerPoints over and over to review the material.

> At first I didn't like that she would not give the PowerPoint ahead of time but would send it after class, but now I do the same with my kids, too. If I give them the notes ahead of time, they think they do not have to pay attention because the already have the information. That was her thinking, too. (I)

Amy reported that she used the same labs in her own class very inexpensively and taught the concepts to her students the same way she was taught in the NSCI courses. "The best thing about the biology, though, was the idea of the cheap labs. Dr. L modeled that we could do outstanding labs, but they didn't have to be expensive."

Amy reported that the classes in science during her teacher preparation, especially the NSCI integrated series, promoted her confidence to teach science material to her students. "Overall, I began by being confident as a student during class and that spilled over to my teaching." She reported that actually participating in the content and activities that she would later use with her own middle school students promoted her confidence. She reported that she still has many of her projects and artifacts displayed in her room, which serve as models to her students on occasion. "You can see that I still have some of my projects around here because I like to show them to my students. I feel like I learned a

great deal of content which allows me to be a better teacher" (I). Each instructor in the coursework provided different strategies for teaching science, noted Amy, and that has allowed her to use those same strategies in her class.

> The biggest deal about the NSCI series was that it was integrated; it was really one big, long class and that it made me think about science in a different and better way. I am very open to new ideas and new thoughts and not afraid to try new science methods. I think my confidence is what makes the difference in trying new stuff. (I)

Amy stated that each instructor provided many graphic organizers, note taking opportunities, and a variety of strategies to teach concepts and the vocabulary of science. She noted that she enjoyed working in small groups, especially the jigsaw activities, and playing around with science to solve problems. "I loved doing the scenarios that allowed us to play around with the science. We did the activity first and then learned the vocabulary about it. Some folks didn't like that because of their differing learning style, but it worked for me" (I).

Amy reported that she appreciated the fact that the class was being taught to the standards that she would be using in middle school and that the students learned the actual material that they would be using with their students.

> Now as I look back on the class I was learning the information as a student so now I can know how my students feel. I can know the range of responses, for example, and I can know misconceptions that they will come up with. This allows me to deal with their misconceptions early. (FG)

Amy reported that one of the biggest experiences that promoted her confidence was doing the work, completing the projects, and actually going through the actual experience that her students would. "The struggle was the overwhelming thing for me; I had to struggle through the activities, struggle through inferring, struggle through the

physics labs that I didn’t have a clue about…this allowed me to learn it. It was always about the struggle.” (FG)

Amy reported that her work at her college has allowed her to be a confident teacher and also a confident colleague. Amy noted that her colleagues often sought her out for science advice as a teacher, especially the younger colleagues.

> I was open to whatever the professors suggested and felt like they were showing me what I should do when I taught. I was learning to teach as I was learning the content. I do not know if the younger folks in class came out of the classes where everything was taught separately so they had a harder time with this integrated method. Some of them didn’t seem to work as hard as they have could have. Because I was older, they thought of me as their study buddy or their mom because they saw how hard I worked and how much I studied. (I)

Amy indicated that the best activities for pre-service teachers were those that allowed the pre-service teacher to do the work of the science student.

> The burning questions, for example, allowed me to struggle with science questions, research something that I was interested in and then share my answers with other students. This works in my classroom for my students the same way it worked for me as a participant in the NSCI classes. (FG)

This participation in the middle school science teaching field has translated in Amy’s feeling of confidence as a science teacher and allowed her to try new things and not give up when her students do not understand the concepts the first time through. She emphasized that making a difference in the lives of her students was very important to her. She mentioned student achievement as a top priority.

> As a confident teacher, I am the facilitator. I give my students a task and let them go. I like to see them struggle. I keep going back to that struggling. They are not always right the first time and sometimes they learn more from the wrong answers. It is all about the predicting, and inferring, and problem solving and the struggle. (FG)

Amy reported that she would have liked to have visited some middle school labs. Seeing how the teacher actually held lab, safely, with 28 middle schoolers would have

been a profitable experience. “We go to do some observations during blocks and some teaching and then, of course, there was student teaching, but I think that if we had seen some science labs right when we were learning it, it would have been helpful.”

Emerging Themes

As the data were analyzed by the constant comparative process, several themes emerged as affirmations by the three participants. I present these in Table 3.

From this matrix, five assertions were developed using a constant comparative process. The constant comparative method involved using a visual wallpaper approach to data analysis. After each interview the audio taping was transcribed and printed in an ink color unique to the participant. These transcriptions were then taped around my office and moved and retaped as themes emerged based on new data from other participants and from the jot-list assignment and then the focus group. After analysis of the data and organization through a matrix, the following assertions emerged:

1. Preparation promotes confidence.
2. Confident instructors use a variety of teaching strategies.
3. Pre-service teachers’ learning style and/or stage of life influences their confidence.
4. Confident teachers result in confident students which often results in higher student achievement.
5. Confident teachers are willing to share their knowledge and skills with others.

These assertions will be explored in depth in Chapter 5.

Table 3

Key Word Matrix for Emerging Themes.

Theme	Jack	Ewen	Amy
Preparation promotes confidence	Predict misconceptions; Review concepts; NSCI courses; Student teaching Exposure to content and strategies from instructors; Feedback from instructors; Projects with rubrics;	Know content; Know how to teach it; NSCI courses: Student teaching; Experience; Gaining strategies from instructors; Being prepared for each lesson; Seeing the projects from a student's perspective	Know subject matter; NSCI courses; Student teaching; Organized; Anticipate questions and misconceptions; Struggle though the activities during coursework; Prior experiences during coursework promotes confidence to use with middle grades students;
Instructors	Confident instructors; Taught content the way middle grades teachers should teach it;	Confident instructors; Taught both content and strategies; Passion for instruction and science; Humor; Became role model; Instructors taught as he should teach it to middle schoolers	Confident instructors; Taught the way they wanted participants to teach in middle school; Promoted struggle for participants; Integrated content over the courses;
Strategies	KWL; Ticket out the door; Charts; Scaffolding; Prior knowledge activation; Graphic organizers; Manipulatives; Questions by teacher and by students; Engaging strategies; Inquiry; Playing around with science; Vocabulary through experience; Integrated lab activities; Science fair project; Projects with rubrics; Technology with PowerPoint and WebCT	EATS; KWL; Essential questions; Activating prior knowledge; Concept maps; Venn diagrams; Engaging strategies Vocabulary through action; Questioning strategies; Inquiry labs; Demonstrations; Hands-on activities; Real life activities; Burning questions; Summarizing; Jigsaw; Small groups; Carousel brainstorming	Inquiry labs; Science dialogue; Small group; Higher order thinking skills activities; Hands-on activities; Projects with rubrics; Vocabulary taught in discussion; Questions; Addressing misconceptions

(Table continues)

Theme	Jack	Ewen	Amy
Experience	Student teaching; Doing labs in NSCI; Teaching content; Confident teachers lead to confident students;	Student teaching; Doing labs in class; Teaching content before; Confident teachers promote confident students	Student teaching; Previous experience with labs; Confident teachers promote confident students;
Life stage/learning style	Nontraditional student; Learning styles met through many different activities;	Older student; Worked hard; Saw the goal of teaching; Need to do the activities	Older student; Worked hard; Willing to try new strategies; Need for many experiences in class especially with inferences
Helping colleagues	Sharing strategies with others;	Total professional; Share with others; Help others improve their teaching; Member of a team;	
Modeling	Modeling from instructors how to teach; Exposure to content and teaching strategies; Modeling for students in the middle grades how to be confident students;	Modeling of instructors how to teach the content to their students;	Modeling of instructors how to teach the content to students while teaching to middle grades science standards; Modeling science dialogue to students so they talk like real scientists
Promoting student achievement	Confident teachers promote confident students which promotes higher student achievement;	Student achievement promoted through confident teaching; Changing up activities to keep students engaged;	Student achievement is top priority;
Teachers who are not confident	Read the book and answer questions;	Do not speak up in meetings;	Reading science text aloud to keep order; Have the same misconceptions as students Not willing to address misconceptions; Assignment givers;

Summary

The three participants completed individual one-on-one interviews, a jot-list assignment, and a focus group. The data were audio recorded, transcribed, and analyzed based on a constant comparative process. The data were reported in this chapter based on

each of the participants' responses. Nine themes emerged as the data were analyzed, as outlined in table 3. Each of the key informants considered himself or herself as a confident teacher and attributed much of their confidence to participation in the NSCI series. Each participant mentioned that his or her life phase contributed to his success as a novice teacher and as a student during the pre-service program. The instructors of the integrated science courses were mentioned as having a positive influence in the key informants' confidence to teach science as well as the experiences and strategies used in the courses. The modeling by the instructors was emphasized as an important element in their pre-service experience and that helping others and promoting student achievement were important contributing factors to confident teachers.

CHAPTER 5

CONCLUSIONS

Introduction

The intent of this study was to record the descriptions of three novice teachers who were members of a cohort who took a series of integrated science courses (NSCI science sequence) during their teacher preparation program. My goal was to allow the participants in the study to describe their confidence in their ability to teach science content as it specifically related to the previously completed NSCI series. The three participants were novice teachers during the 2006-2007 school year and were teaching middle school science. They were identified by contacting a pool of 21 teachers who met all of the qualifications of the study, which included being willing to participate, having completed all three NSCI courses, and being novice teachers (within their first 3 years). Two of the key informants were teaching in the same large metropolitan school system, and the other was teaching in a similarly large metropolitan school system. Three data sets included an open-ended interview and a focus group as well as an assignment that suggested they make a jot-list of activities that they were using in their classrooms that they completed during the NSCI series.

The structure of the final chapter begins with the five assertions resulting from the data. Other sections include discussing the significance of the study, relating the assertions back to the theoretical framework, implications for science education, implications for future research, and some personal reflections.

Assertions of the Study

Assertion 1: Preparation promotes confidence.

The three participants were very clear that preparation promoted their confidence to teach middle grades science. All commented that the NSCI courses resulted in their being well prepared to teach middle grades science. The overriding strand that resulted from analysis of data in this area was that they appreciated being taught the way they were to teach the material to their students. Completing the activities, being involved in the labs, and actually generating artifacts such as scrapbooks, science projects and research papers allowed them to learn to teach while learning the content.

Each of the participants referred to being able to see the coursework from the student's perspective as an important element of their teaching confidence. Jack repeatedly referred to the "exposure" to the content, but also "exposure" to the modeling of the instructors. He felt as though he were well prepared because he was taught by instructors who not only understood their content very well, but also understood middle school students. The instructors provided feedback to the NSCI students about their coursework, class work, and projects. This allowed the students, according to Jack, to meet the standards of the instructors. His experience, for example, of doing the labs in NSCI and then doing the labs with his students allowed him to be more confident of his ability to involve his students in the lab work.

Ewen reported that seeing the content and activities from the student's perspective was instrumental in promoting his confidence as a middle school science teacher. As he observed the NSCI instructors, he was doing exactly as Lortie (1975) predicted: He was learning to teach as he was learning the science. Lortie termed this "apprenticeship of

observation." Ewen observed that the instructors were strongly passionate about their topics and understood them thoroughly. He was attracted by the fact that they modeled in their courses how to teach the science to middle school students. He mentioned that Dr. P actually became his role model for teaching his students. He noted that he gained a variety of strategies for teaching the content in the NSCI series that he uses with his middle school students.

Amy reported as well that the NSCI series promoted her confidence to teach middle school science. Her perspective seemed to center around the "struggle" that she felt while actually completing the coursework. She indicated that by actually doing the work, studying for the tests, "struggling" with inferences, and seeing everything from the student's perspective, she became a confident science teacher.

The NSCI series, then, was an overwhelmingly positive component of the three participants' feelings of confidence. It was clear from their interviews and discussion that they felt that the NSCI series instructors were able to combine content with pedagogy to promote their confidence as middle grades science teachers.

The National Research Council (1996) and the American Association for the Advancement of Science (1989) have based their standards on the philosophy that students are active learners who learn best when they are constructing their own knowledge. These participants indicated that the constructivist model that was used in the NSCI series was based on this vision and supports the model of teacher preparation that provides teachers with a framework for their own classroom. The idea of a learner-centered classroom is now often the focus of teacher preparation programs. The pendulum has swung from the teacher's being the focus of the classroom to emphasizing

the importance of the student's being the focus (Hewett, 2003; McCombs, 1997; Reilly, 2000). Henson (2002) reports that "the role of the instructor is not to put knowledge into learners' heads, but to put the learners in positions that allow them to construct well developed knowledge" (p. 13). In this case, the professors were not just the "sage on the stage" (Lehr, 2002) but were facilitators of the knowledge and pedagogy so that the pre-service teachers became the active learners.

The participants also noted the integrative nature of the NSCI series: Content and methods were taught concurrently. Danielson and McGreal (2000) emphasize the interdependence between the content and the methods by which the content is taught. I found it surprising that in our conversations not one of the participants mentioned a "methods" course although I know that they were required to take them. The methods course is one where students learn how to teach through the modeling of strategies, the generation of lesson plans, and practice teaching experiences in a safe environment. These are typically valuable courses, from my experience. However, these participants focused almost specifically on the NSCI series with a content/pedagogy integration. Obviously, Beckman's work (2001) indicating the lack of communication between the content and the methods courses was not a consideration here. The participants valued the combination of the two in this series of courses. Duggan-Haas (1998) indicated that teacher candidates are often conflicted because of the different agendas of the science program instruction and the teacher education program. Again, because of the integration of science and teacher preparation in these courses, the participants appeared to be clear on both the science content and the pedagogical considerations. Good teacher preparation programs, according to Darling-Hammond (1998), include a coherent curriculum that

tightly intertwines theory and practice. This describes the relationship between theory and practice in the NSCI series.

In 1998, van Driel, Verloop, and de Vos found that there was value in having prospective teachers study content from a teaching perspective. Allowing content and pedagogy to be taught simultaneously will promote the teacher’s ability to promote scientific literacy and transform science content into learning opportunity. In fact, it is the intersection of content and knowledge that Shulman (1986) refers to as pedagogical content knowledge. Duggan-Haas et al. (2001) indicate that a new model of teacher preparation must emerge if science education is to prosper. This new model will be based on standards that integrate content and pedagogy in teacher preparation programs. This new model was used in the NSCI series and is supported by the descriptions of the confidence of these three participants.

Craven and Penick (2001) indicate that exemplary science teacher preparation programs should be composed of courses that involve rigor, higher order thinking skills, and inquiry. The participants for this study give evidence that these were included in their preparation program, especially in the NSCI series. All three participants noted that they considered the instructors to be confident in their abilities mostly because of their complete understanding of their content. The National Science Teachers Association (2003) Standards for Teacher Preparation indicate in Standard 1 that teachers must have a thorough understanding of science and be able to convey to students the major concepts, principles, theories, laws, and interrelationships of the science fields. The NSCI series has modeled the teaching of science by science specialists who are able to transform this information for their pre-service teacher’s content. This has avoided what some refer to

as the “bifurcation of content and teaching processes” (Shulman, 1987; Duggan-Haas et al., 2001).

Another element that appeared in the matrix for all three participants was the aspect of modeling. Brooks and Brooks (1993) and Bruce and Showers (1988) indicate that modeling might be the most important element of teacher preparation because adult learners are more easily influenced by what they see as opposed to what they are told.

Another item that was mentioned by all three participants was their student teaching experience. As might be expected, having a student teaching experience that allowed each of the three participants to work under a master teacher in the science classroom promoted their confidence in their ability to teach science. Teacher preparation programs must have a balance of theory and practice. Opportunities must be provided for learning and for practice of teaching (Craven & Penick, 2001; McDonnough et al., 2001).

Another element in the area of preparation that promoted confidence was the personal preparation by each of the participants for their students. Each of the participants mentioned that they had to be well prepared to teach each day. No matter how well prepared they were in their undergraduate program or how much content they knew or how well they understood how to teach their content to students, they were personally responsible for being prepared to teach their students on a daily basis. Jack referred to his need for being prepared to address the misconceptions of his students. He emphasized that he often reviewed the concepts before teaching them to his students. Ewen expressed that he knew his content and he knew the standards that are required of the state and system for his subject area, but he also knew how to teach it to his students. His emphasis

on being prepared, posting the essential questions, using a variety of strategies, and "changing things up" evince his need for preparation for his classroom.

Amy indicated that she knew her subject matter well, was prepared to anticipate questions from her students, and was able to address their misconceptions. Amy indicated that her organization added to her confidence level. She stated that she was not afraid to try new activities or allow her students to guide the lesson because her preparation as a teacher is thorough as is her college preparation and this is further supported by her excellent organizational skills.

Another component of preparation mentioned by all three participants is experience. All mentioned that having taught science once already (they are all second year teachers) promoted their confidence to teach science. All mentioned that having a year of experience increased their confidence levels for the 2006-2007 school year. Confidence grows on the job (McDonnough et al., 2001). Research completed by Shalcross and Spink (2002) indicated that the number one way to increase teacher confidence was to teach the subject matter.

Preparation that promoted confidence for these three key informants then came in several forms: the coursework they had completed including the NSCI classes and especially the modeling of the professors, their student teaching experiences, personal preparation to teach in their own classrooms, and their one year of teaching experience. Marzano's (2001) work with accomplished teaching indicates that teachers who have been in teacher preparation programs that provided modeling of specific researched-based teaching strategies while teaching content and then allow students to have opportunities to apply these new skills report a higher level of confidence in their

teaching abilities. Darling-Hammond (2000) indicates that it “may be that the positive effects of subject matter knowledge are augmented or offset by knowledge of how to teach the subject to various kinds of students. The degree of pedagogical skill may interact with subject matter knowledge to bolster or reduce teacher performance.” Having learned the content along with the pedagogy enhanced the effectiveness of these teachers. This is confirmed by all three participants.

To produce teachers with high pedagogical content knowledge in science, the National Science Foundation and National Research Council have recommended that university teacher preparation programs do the following:

1) *integrate* content and methods courses;
2) form *relationships* between education and science departments and the K-12 sector;
3) introduce *experiences* that help pre-service teachers prepare for teaching science; and,
4) provide opportunities for pre-service and in-service teachers to *interact* (Duggan-Haas et al., 2001)

The data provided by the three participants indicated that the NSCI courses have followed the lead of work in the teacher preparation field that result in confident teachers with a high degree of pedagogical content knowledge.

Assertion 2: Confident instructors use a variety of teaching strategies.

All three of the participants indicated that they felt that the instructors of the NSCI series were confident instructors. This was evidenced by the variety of strategies used by the three instructors. Each instructor, according to the participants, appeared to have their own preferred strategies that were recalled by the participants. Dr. P, for example, used a variety of strategies to teach vocabulary. The participants reported that he would often have the students complete the activity with little direction and then afterwards would put the vocabulary to the actions. Dr. E, for example, used many hands-on demonstrations to

teach the concepts in geology. Ann reported that Dr. E's use of inference really influenced her use of inference in her own classroom. Dr. L. used many PowerPoints as reported by the key informants that allowed them to follow the lecture and later use them for review of the material.

In turn, the participants indicated that the use of a variety of strategies was an indication of their confidence in their ability to teach science content to their students. All participants mentioned the use of hands-on activities and especially inquiry labs that promoted thinking on the part of their students. Many strategies were listed by each of the participants as engagement strategies that kept the students from being bored. This appeared to be very important to these three teachers. Ewen, for example, kept referring to "changing it up" in his classroom. Jack used a strategy for turning the questions back on the students as an engagement strategy that promotes higher order thinking. Amy used discussion as a tool for getting students actively involved with the science vocabulary and science topics. Each of the participants indicated that they needed to use a variety of strategies in their classrooms and because they were confident teachers, they do not rely on just one. They each indicated, also, that teachers who are not confident resort to reading the textbook, answering the questions, keeping order, keeping busy, and avoiding science discussions. They attributed this lack of confidence to not knowing the science material well enough to teach it in engaging ways.

Confident and effective teachers must have knowledge and understanding of science content and science instruction. They must understand how best to teach the key concepts (Goody & Wilson, 1996). The American Association for the Advancement of Science (1989) indicates that effective science teachers ask questions, engage students

actively, promote the understanding of vocabulary, and use a variety of research-based strategies for teaching science. The three participants, as evidenced by the list of strategies they prefer and their conversation about their classrooms, indicated that they have been exposed to and have implemented in their classroom strategies that confirm that they are, indeed, confident teachers. NSTA (2003) indicates that inquiry (Standard 3) is a vital component of a science teacher program. They indicate that this component of inquiry-based labs must be explicitly modeled in the pre-service classroom. According to the participants, they found this to be the case in the NSCI series.

Assertion 3: Pre-service teachers' learning style and/or stage of life influenced their confidence.

Each of the participants referred to both their learning style and their stage of life as something that may have contributed to their confidence level. Each of the three participants were nontraditional students: They came to this science education program after other college majors, having another career, or raising children, and they considered teaching to be "their calling" or their desire "to make a difference," especially to students in difficult situations. They all indicated that because they were older students, they observed that they were willing to work harder because this was not going to be just a job to them: It was a career. All three stated that they worked harder than most of the younger students around them to learn the content and were more serious about their studies. They mentioned that while they did not always recognize that they were being taught content and teaching strategies during the courses, the debriefing by the instructors and their feedback during the courses did promote a deeper understanding of the content and

pedagogy. The “younger” college students may not have picked up on the dual nature of the course, from the perspective of the participants.

Because all three participants were more middle-aged adult learners, it was important to consider the adult learning theory information. Adults come to learning events with very different expectations than do children or adolescents. Merriam and Caffarella (1999) indicate that the adults are more problem centered, their readiness to learn is based on the tasks that are set before them, and their motivation is based more on internal motivation (e.g., desire to learn, hope to make a difference) than external (e.g., grade, sticker). Adults take a leadership role in their own learning and tend to prefer job embedded experiences and those that make sense to their understanding of their roles and responsibilities either now or in the future (Hewett, 2003; Knowles, 1980; Tennant & Pogson, 1995) Knowles indicates that a relationship between the adult learner and the instructor is of prime importance to the adult learner. The development of such positive relationships between pre-service teachers and college faculty has been shown to be important to the success of nontraditional-age learners (Knowles, 1998; McDonnough et al., 2001; Rodrigues & Sjostrom, 1998).

All three participants indicated that as nontraditional students they appeared to work harder and were more serious and purposeful about their education. This was probably a result of their feeling of being “called to teach.” Also, they all referred to interactions between themselves and the instructors that resulted in deeper understanding of the content and pedagogy. Ewen referred to Dr. P as “his male role model” and Amy indicated that Dr. L was especially helpful with meeting her to provide extra support with inferences. Relationships among faculty and students provide a new dimension and often

result in greater learning on the part of the students because the instructor is more likely to understand the students' needs and backgrounds and tailor instruction accordingly. These relationships between faculty and pre-service teachers are also providing a model for future teacher-student relationships in their own schools (Dinsmore &Wenger, 2006).

Perry's (1998) work with stages of college students indicates that the students in this research study were probably in stage four. His four stages involve dualism, early multiplicity, late multiplicity, and contextual relativism. The fourth stage involves the teacher's becoming a resource from the perspective of the student, and the student's job is to acquire the information and apply it. Mastery of the information may not be as important as how to apply it to specific situations. The participants indicated by their data that they were very intent on learning the material for future application. They were willing to be involved in all aspects of the NSCI course and wanted to be involved in the dialogue and discussion that would result in deeper understanding of the material.

All three participants also indicated that their differing learning styles influenced their full participation in the courses. All three mentioned that they learned better when they were actually participating in the science as opposed to reading about it or hearing about it. Jack indicated that his exposure to the material through actually doing it was his preference for learning. Ewen agreed that doing the activities went right along with his learning style. He indicated that the use of PowerPoint did not support his learning style during one of the courses, but the activities allowed him to learn the material. Amy indicated that she learned best by participating also, and she continued to use the word "struggle" when she referred to participating in the class. All three indicated that they

used a variety of strategies in their own classrooms to meet the learning style needs of their students.

The NSTA (2003) Standards for Science Preparation address learning styles in Standard 5 as they discuss the general skills of teaching. They indicate that the teacher preparation program must provide coursework that allows their teacher candidates to demonstrate their ability to vary their teaching strategies based on the needs of their students. For this to occur, the instructor must have an understanding of his or her learning style as well as his or her teaching style. Ouellette (2000) indicates that one of the most important roles of the instructors is to help their pre-service candidates build a repertoire of strategies that will appeal to their future students. This does not mean necessarily that the instructor must teach to each student individually. But rather the instructor must provide a variety of strategies so that the preferred learning style of each student is emphasized at some point (Ballone & Czerniak, 2001; Darling-Hammond, 1998; Felder & Silverman, 1988).

One of the guiding principles of the National Science Education Standards (NRC, 1996) is that if science is to be for all students, then the curriculum and instruction must be designed to meet the needs, abilities, interests, understandings, and knowledge of all students. If teachers believe that all students can learn, then they are accepting the belief in the diversity of all learners including learning styles. Darling-Hammond (1998) states,

> We know that teachers need to know their content areas. And it matters even more how much they know about student learning. They need to know how to design and develop curriculum and diagnose student needs, so they are scaffolding students' learning in careful steps.

Felder and Silverman (1988) consider that there are five questions that will allow instructors to determine the learning styles of the students in their science classroom.

These questions are "What type of information does the student prefer? Which modality is sensory information most effectively perceived? How does the student prefer to organize information? How does the student prefer to process information? How does the student progress toward understanding?" (as cited in Felder, 1993, p. 286)

Okebukola (1986) found that students perform better when they are in an environment that takes their learning preferences into consideration. Students whose learning styles in the college classroom were compatible with the teaching style of the instructors tend to retain information longer, apply it more effectively and have more positive post-course attitudes toward the subject than do their counterparts who experience learning/teaching style mismatches (Ballone & Czerniak, 2001; Darling-Hammond, 1998; Felder, 1993).

The participants in the study overwhelmingly believed that the instructors promoted their confidence by teaching to a variety of learning styles. Those who learned best by doing appreciated the hands-on activities. Those who preferred visuals and lectures were provided those activities throughout the class. Those who learned best by reading, research, and reviewing were given that opportunity. Jack stated that the series was like the "United Nations of learning styles." It appeared that these participants felt more confident because of some measure to their learning styles preferences being considered and instruction being tailored to their diverse needs.

Assertion 4: Confident teachers result in confident students, which often results in higher student achievement.

Each of the participants indicated that increased student achievement was their top priority. All used in their interviews practically the same comment: "Confident

teachers promote confident students, which promotes higher student achievement." Each of the participants felt that their ability to teach confidently was very much affected by their participation in the NSCI series, which they felt was taught by confident instructors. This, in turn, promoted their confidence to teach science. Their preparation in the NSCI courses allowed them to feel confident in their own abilities to teach science content. They all agreed that their primary goal as the science teacher, then, was to promote their students' confidence as learners of science. They all indicated that this increased confidence resulted in higher student achievement.

Confident, effective teachers affect student achievement. Teachers who have confidence will persist in the face of challenges, will provide a greater focus on instruction in their classroom, and will be involved in more effective forms of feedback than those who have less confidence in their ability to affect student growth (Gibson & Dembo, 1984).

All three participants indicated that they had confidence that they were able to make a difference in their students and that they made every effort to use strategies in their classroom that resulted in student growth in the area of science. Multiple studies have documented that strong self-efficacy beliefs are linked to high student achievement and increased student motivation (Henson, 2001). The Rand Corporation studies in the 1970s, for example, indicated a strong link between teacher efficacy and student achievement (Chase, Germundsen, Brownstein, & Distad, 2001).

However, it must be noted that the TIMSS Benchmarking Science Report (Mullis et al., 1999) indicates that the three highest performing countries based on academic scores, Hong Kong, Japan and Korea, reported that half the students had teachers who

felt only somewhat prepared or less. Science teachers in the United States overall generally reported greater confidence in their preparation than did their peers in other countries even with lower test scores. Although confidence in teaching the subject matter would seem to be a strong indicator of success, there is need for more strong quantitative research that indicates that confidence consistently results in higher student achievement.

Assertion 5: Confident teachers are willing to share their knowledge and skills with others.

Both Jack and Ewen indicated that because they were confident teachers, they were more than willing to share their teaching strategies with other teachers. Jack indicated that many teachers in his school have come to him for advice on how to teach science in an engaging manner. Ewen reported that when one is confident he is a “total professional” and this includes sharing the skills and knowledge to be a confident science teacher with others on his team. Ewen felt strongly that he was a member of a team, and he had a responsibility of help improve the teaching of all teachers.

Wong (1997) writes that one way to improve confidence is to be involved in collegial conversations and formal discussion about content and pedagogy. Chase et al. (2001) indicate that reflective practice groups where teachers discuss their practice improves teacher efficacy and, in turn, results in increased student achievement. So while Jack and Ewen stated that their sharing with others was a result of their confidence, it may be that they were becoming more confident teachers as they were involved in formal and informal conversations about their teaching practice. Dinsmore and Wenger (2006) reported that pre-service teachers working in communities learn the material better and retain it longer than those who do not have a sense of community. Sharing with one

another, especially veteran teachers with novice teachers, promotes confidence of novice teachers (McDonnough et al., 2001).

Significance of the Study

Teachers often report there is a disconnection between the coursework that they take in college and the reality of their first years of teaching practice (Craven & Penick, 2001). In this study, questions were posed during one-on-one interviews and a focus group that centered on the confidence of three novice teachers to teach middle grades science. I asked the three participants to reflect on a series of courses that all had completed during their teacher education program and the influence these courses had on their confidence level. All three participants overwhelmingly agreed that the NSCI series using an integrative approach to teaching science while modeling the appropriate pedagogy for middle school students had a direct and positive influence on their confidence to teach middle school science.

Craven and Penick (2001) suggested that a vital component for an exemplary teacher education program is a mechanism for feedback. Former students might be one such resource to provide information about the effectiveness of programs. In this study, three participants were give the opportunity to provide specific feedback that related the coursework to their confidence to teach middle grades science content to their students. This will allow informed decisions about the future of teacher preparation programs, in this case the NSCI series.

Relating the Findings to the Theoretical Framework

The theoretical framework for this study was based on pedagogical content knowledge. PCK involves the teacher’s understanding the content of science so

thoroughly that he or she identifies ways of representing and formulating the subject matter to make it understandable to his or her students. The teacher who has a strong grasp of PCK uses powerful analogies, illustrations, examples, explanations, and demonstrations that promote student understandings that are personally meaningful (Shulman, 1986). Those with a strong PCK use a variety of strategies for teaching the concept, are able to understand and teach the big ideas of science, and anticipate and address student misconceptions (Grossman, 1990). Schwab (1964) indicates that PCK influences the way teachers provide for discourse and questioning of students in their classrooms. Four areas that are often referred to in discussion of PCK involve the teacher’s goals for their students for specific content, knowledge of students in their classroom and understanding how this knowledge will affect their teaching of the content, curricular knowledge and how the scope and sequence of the topic should be arranged, and finally, specific instructional strategies that promote learning (Grossman, 1990). The novice teachers involved in this study, although never using the term pedagogical content knowledge, indicated that they have a fairly evolved PCK.

Each of them indicated that they had student achievement in mind as they planned for their lessons and units and that they were guided by district and state goals and objectives as they planned for their lessons. They indicated that they vary the instruction based on the needs of their students and use appropriate activities to demonstrate the content to their students.

Veal (1998) indicates that PCK is highly specific to the content, in this case science, and that it evolves over time. Gudmundsdottir (1991a) describes part of PCK as orientation: what teachers value in the classroom. This influences how they teach, what

they teach, when they teach, and, perhaps, if they teach the content. Each of the three participants was specific about what they found valuable in the classroom. Jack indicated that he wanted students to think about their content as they were “playing around with science.” This is revealed through the many strategies that he uses in his classroom to make the science curriculum real and interesting to his students. His emphasis is on “exposure” to the content and to activities that promote deep understanding of the content for his students. Ewen found real life activities valuable for his students as well and valued the use of essential questions and activating prior knowledge as evidenced by the list of strategies he used on a regular basis in his classroom. He valued variety and “changing up” activities to promote confidence and higher achievement. Ann valued the “struggle” as she structured for higher order thinking skills in her classroom and promoted a high level of discussion requiring authentic science vocabulary. All three teachers gave evidence of having a fairly sophisticated level of PCK, which in turns appears to have given them a feeling of confidence in their ability to teach science to their middle school students.

Novice teachers, according to Shulman (1986) and Cochran et al. (1993), sometimes find it difficult to merge their content knowledge with their pedagogical knowledge because of lack of experience. When this happens, the novice teachers resort to more traditional, direct-instruction models of teaching and use low-level questioning. The novice teacher with a more advanced level of PCK is able to consider students’ backgrounds, learning styles, misconceptions, and preconceptions and is able to make informed decisions about his or her practice based on these understandings (Carlsen, 1987; Wilson et al., 1987). These three novice teachers seemingly have had the

experiences necessary either through the NSCI coursework, student teaching, their first year of teaching, or personal reflection to have the ability to combine their knowledge, content, and PCK to formulate lessons that consider what is often called context.

Implications for Science Education

This type of study will allow those who make decisions about science teacher preparation programs to make more informed decisions based on the feedback from their former students. Based on the descriptions of these three participants, courses where science is integrated, both content and pedagogy are weaved together, and where the standards and expectations for the future students are considered result in teachers who feel well-prepared and confident as science teachers.

Implications for Future Research

A future research study might involve the visiting of the classrooms of the three participants. Although they all indicated through their conversations that they were confident teachers, it would be valuable to observe the classrooms of the participants and see if the level of confidence they state is actually evinced in their classroom practice. Are they actually implementing the activities that they have reported in this study?

Further areas of research include interviewing their students to see if, in fact, the confidence of their teachers is being transferred to their students. Another interesting area of research would be comparing the perceptions of confident teachers to the actual student achievement data to see if there is some correlation between or among teacher confidence perceptions and their student achievement data.

Personal Reflections

As a student in this series of NSCI courses, I wondered if my fellow students were observing what I was observing. Did they know that we were being taught both content and pedagogy? Did they realize that we were being taught the science by using strategies that would be successful with our middle grades students? Were these classes going to promote their confidence to teach middle grades science content?

Through this study I discovered that although they did not always know it at the time, this series of courses modeled for these three participants the appropriate science content and pedagogy for middle school science teachers. Throughout the data collection, the participants continued to refer to the expertise and knowledge of the instructors and the integrated nature of the courses, both in the science integration and the integration of content and pedagogy. They made connections between what happened in the NSCI coursework and the reality of their first years of teaching. They recognize now (and to a lesser extent during the coursework) that they were involved in a valuable experience where well-respected science instructors used their knowledge of their topic to teach education majors how to teach with the appropriate middle school strategies. I am pleased to report that the three participants who were students in the NSCI series found the series to be as valuable as I did. As a result of their involvement with the NSCI series, these participants indicate that their confidence level is high and they are using strategies in their classrooms that they learned from their confident instructors.

Preparation for this study has allowed my knowledge base of several areas to be increased. I have been influenced greatly by the work of Shulman, Duggan-Haas, and Grossman in the area of pedagogical content knowledge. Knowledge of content and

knowledge of pedagogy influence confidence levels of teachers. Being aware of the research in the field has allowed me to gain a deeper knowledge of teacher behaviors that support student achievement.

I have also been influenced by the work of McCarthy (1987) and Hanson et al. (1996) in the area of learning styles. Teachers who are able to understand the unique differences among their students and differentiate their programs promote student achievement and improve student motivation.

Finally, I have gained a deeper knowledge of the standards for science education through my reading in the area of the NSTA standards and especially their review by Duggan-Haas et al. I am better able to articulate the standards for teacher preparation, understand their importance, and see evidence of them in the classrooms I serve.

Summary

Three participants who completed a series of science courses (NSCI) and were novice teachers during the 2006-2007 school year were involved in one-on-one interviews and a focus group. They provided data that indicated the following:

1. Preparation promotes confidence.
2. Confident instructors use a variety of teaching strategies.
3. Pre-service teachers' learning style and/or stage of life influences their confidence.
4. Confident teachers result in confident students which often results in higher student achievement.
5. Confident teachers are willing to share their knowledge and skills with others.

Through this research study, the three participants concluded overwhelmingly that there were several experiences that promoted their confidence to teach middle school science and this confidence has resulted in their ability to use multiple strategies in their classrooms for higher student achievement. Their confidence has also resulted in their ability to share their successful classroom practice with other teachers. These experiences included the NSCI series taught by well-respected, confident instructors who taught the content of science while modeling the appropriate pedagogy. Another experience that promoted their confidence was their student teaching under the tutelage of a master teacher. Experience, of course, promoted their confidence, as having taught the material once contributed to their feeling of confidence in their ability to teach science content to their students.

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APPENDIXES

Appendix A

Email Recruitment

The topic of my dissertation is the influence that certain courses might have on the confidence of teachers to teach science content to middle school students. The coursework for this study is the NSCI series of integrated science courses that middle school teachers completed for middle school certification. Since you have completed that series, I am asking for your voluntary participation in my research study. The study involves a one hour interview at a site that is convenient for the participant and a two hour focus group meeting at a neutral site that is convenient for the group

Six participants will be chosen for this study. No participant information will be identifiable since alternate names will be used throughout the study. Study information will be stored in separate locations from the participants' information so that no one will have access to personal data. Willing participants will have the option to drop out of the study at any point. Each participant will be asked to sign a consent form that allows their data to be used in the study even though no data will be identifiable to a specific participant.

Appendix B

Georgia State University

Department of Middle- Secondary Education and Instructional Technology

Informed Consent

Title: LEARNING TO TEACH: DESCRIPTIONS OF NOVICE TEACHERS ABOUT THEIR CONFIDENCE IN TEACHING SCIENCE CONTENT

Principal Investigator: Barbara Ann Ford

I. Purpose:

You are invited to participate in a research study. The purpose of the study is to investigate your perception of your confidence to teach middle grade science. You are invited to participate because you are are a novice teacher during the 2006-2007 school year and have completed all of the NSCI science courses as part of your preservice education at Georgia State University. A total of six participants will be recruited for this study. Participation will require four hours of your time over four weeks. An interview (approximately 1 hour in length) and a focus group (approximately 2 hours in length) will be the extent of your participation. Email correspondance will give each participant the opportunity to provide feedback at the end of the study which should take no more than 1 hour.

II. Procedures:

If you decide to participate, you will be scheduled for a one on one interview with the principal investigator. The location for the interview will be a neutral site if that is agreeable to the participant. This interview will take approximately one hour and will be audio recorded for accuracy. A focus group with all participants will meet for a two hour session during the last week of the study at a classroom site on the Georgia State University campus or another mutually agreeable neutral site. Email correspondence will be provided at the end of the study to provide for member checking.

III. Risks:

In this study, you will not have any more risks than you would in a normal day of life.

IV. Benefits:

Participation in this study may not benefit you personally. The benefit may be to teacher education program research. . Overall, we hope to gain information about any influence that the NSCI courses may hold for pre-service teacher's confidence in their ability to teach middle grade science.

V. Voluntary Participation and Withdrawal:

Participation in research is voluntary. You have the right to not be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time. You may skip questions or stop participating at any time. Whatever you decide, you will not lose any benefits to which you are otherwise entitled. This study will have no affect on any future programs at GSU nor will it have any affect on your teaching status.

VI. Confidentiality:

We will keep your records private to the extent allowed by law. We will use a pseudonym rather than your name on study records. Only the principal investigator will have access to the information you provide. It will be stored at the home of the principal investigator and will only be accessed by the principal investigator. Your name and other facts that might point to you will not appear when we present this study or publish its results. The findings will be summarized and reported in group form. You will not be identified personally. The key that identifies participants will be stored in the work office of the principal investigator and may not be accessed by anyone other than the principal investigator. The key will be destroyed when the dissertation is published. All tapes will be destroyed on the publication of the dissertation. Pseudonyms may be used during focus groups; however, it may be that the participants will recognize one another from classes. Everything possible will be done to provide for confidentiality of all participants. All email correspondence will be stored until the dissertation is published. All records will be destroyed at the publication of the dissertation. Any electronic information will be stored on a password protected computer.

VII. Contact Persons:

Call Barbara Ford or Dr. Lisa Martin Hansen at (770) 473-2795 or lmartinhansen@gsu.edu if you have questions about this study. If you have questions or concerns about your rights as a participant in this research study, you may contact Susan Vogtner in the Office of Research Integrity at 404-463-0674 or svogtner1@gsu.edu.

VIII. Copy of Consent Form to Subject:

We will give you a copy of this consent form to keep. If you are willing to volunteer for this research, please sign below.

____ ________________

Participant Date

____ ________________

____ ______

Principal Investigator or Researcher Obtaining Consent Date

Appendix C

Interview

1. What is your definition of confidence?
2. What do you consider to be confident practices in the classroom?
3. What pre-service or service activities, if any, have had the most influence over your science teacher practice?
4. Were there any events during your pre-service preparation that either greatly promoted your confidence to teach science or diminished your confidence to teach science?
5. Tell me about your NSCI experiences. (Optional, if needed)

Assignment: Please reflect upon your teaching practice over the next two weeks. Jot down in the notebook I have provided any activities, assignments, strategies, etc. that remind you of your NSCI experiences and we will discuss them at the next interview.

Appendix D

Focus Group Questions

1. What pre-service/service experiences do you think best promotes teacher confidence?

2. What experiences, if any, would you like to have had as a pre-service teacher that would have promoted your confidence in your ability to teach science content to your middle school students?