A GLOBAL TO LOCAL CONTINUUM: THE INFLUENCE OF MACRO, MESO, AND MICRO POLICIES ON BEGINNING SCIENCE TEACHERS' INSTRUCTION

by

SHANNON LYNNE DUBOIS

(Under the Direction of Julie A. Luft)

ABSTRACT

The dissertation includes three studies that all contribute to understanding the experiences of beginning science teachers. The first chapter provides an overview of the context of the studies. In Chapter 2, a qualitative study of three first-year science teachers without their own classrooms is presented through a cultural historical activity theory (CHAT) perspective. This study shows how components of school context can influence beginning science teachers' enactments of standards-based science teaching. In Chapter 3, a qualitative, cross-national, and comparative study of 12 beginning science teachers in South Africa and the United States is explored through an institutional theory perspective. This study shows the influence of macro, meso, and micro policies on beginning teachers' actions in a cycle of instruction. In Chapter 4, an extensive literature review on beginning science teachers is described through an international framework. The review synthesizes the research on beginning teachers over the past 30 years, and provides suggestions for future research. The last chapter summarizes the findings and implications of the three studies, and elaborates on the overall contributions of the dissertation to science education.

INDEX WORDS: beginning teachers, science education, context, cross-national, comparative, policy, international

A GLOBAL TO LOCAL CONTINUUM: THE INFLUENCE OF MACRO, MESO, AND MICRO POLICIES ON BEGINNING SCIENCE TEACHERS' INSTRUCTION

by

SHANNON LYNNE DUBOIS

B.S., Syracuse University, 2007

M.A.T., University of North Carolina at Charlotte, 2011

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2014

A GLOBAL TO LOCAL CONTINUUM: THE INFLUENCE OF MACRO, MESO, AND MICRO POLICIES ON BEGINNING SCIENCE TEACHERS' INSTRUCTION

by

SHANNON LYNNE DUBOIS

Major Professor: Julie A. Luft
Committee: Barbara A. Crawford
Peter W. Hewson
Joseph J. Tobin

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
May 2014

DEDICATION

For my parents, Rick and Mary Lou Dubois, who always believe in me and encourage me to pursue my goals; and for Matt, who unwaveringly provides me with laughter, loyalty, and love to achieve them.

ACKNOWLEDGEMENTS

I would to acknowledge the individuals whose support and insights guided me along this educational journey. First and foremost, I would like to thank my advisor and colleague, Julie Luft. Words cannot express my gratitude for all the opportunities you have provided me. You have literally taken me on scholarly experiences from the global to the local. You have spent countless hours advising and encouraging me, and providing feedback on my work. When I felt lost in the research, a conversation with you would tie everything back together. You have taught me to focus on the details, but never to lose sight of the broader messages in the research. I have been fortunate to work so closely with someone so brilliant in our field. I hope that someday I am half the researcher, writer, mentor, and runner that you are. You are an inspiration, and I know that I have been supported by the best. Thank you, for everything.

I also want to extend my gratitude to my committee members, Barbara Crawford, Peter Hewson, and Joe Tobin. Barbara, I always appreciate your kindness and perspectives. Your genuine interest in the graduate students' lives does not go unnoticed. Your passion and knowledge of science teacher education is admirable and I am grateful for our conversations, which often leave me thinking for days. You have taught me to think critically of the terminology I use in my research, and what everything means in the midst of science teaching and science teacher education. Thank you for always sharing your stories and helping novice researchers experience the community of science education scholars – both in and out of classes.

Peter, your insights and intellect have strengthened my thinking and research. Your idea of a South Africa/United States collaborative study expanded my vision and research by allowing me to experience another culture, and better understand my own culture. You are a wonderful scholar, and it has been an honor to work with you. You have taught me that the same tree looks different on different days of the year. This photographic message has implications for my research, as it emphasizes the importance of collecting data at different times and that people's actions are influenced by surrounding contexts. Thank you for sharing your knowledge, which stems not only from scholarship in the field, but from the wisdom of your own life.

Joe, I have enjoyed our conversations and intersections over the past year. You have helped me to understand comparative education research, and understand my research within the field of comparative education. You have consistently challenged me to think critically, and consider local and global factors. You have taught me that the world is not homogenous. Even though there are similarities that exhibit elements of a world culture, there is always diversity on the local levels. Thank you for your expertise and willingness to help me make sense of the data for our cross-national research.

Academically, this journey would not have been complete without the influence of the late Norm Thomson, my first advisor, mentor, colleague, coach, and friend at UGA. You always showed a genuine interest in my life and in my scholarship. You were never too busy for a conversation. You encouraged me to begin my first research project. You inspired me to run – faster, longer, and harder than ever before. It was a privilege to learn from you and work with you. Thank you for being a positive influence on my life and professional journey. Though you are physically gone, your knowledge remains. You are missed, every day.

I also want to thank my peers who have accompanied me on this educational journey. To my dear friends, Baha and Melissa, thank you for all the support and good times, especially this past year, as we get ready to begin the next stages of our professional careers. To my all-star collaborator and friend, Rene, thank you for your incredible dedication to our research project and for the many, many, many Skype conversations that deepened our understanding of two cultures. To my research teammates, Ryan and Ben, thank you for providing feedback on written drafts and presentations, and for just sharing ideas. To all the graduate students in AGSSEPT, thank you for the conversations and friendships that help us maintain our sanity.

I want to extend a heartfelt thank you to my family. Mom and Dad, you are simply the best. You have provided me with educational opportunities, encouraged me to pursue my dreams (even when those dreams took me far away from home!), and supported me through the twists and turns. You have been there for me through every project, every paper, and every milestone. Thank you for always being my biggest fans. For my brother, Keith, you have consistently tried to show me perfectionism is an unrealistic goal. Thank you for reminding me that some days, you just need to wear sweat pants.

And last, but certainly never least, for my love and best friend, Matt Navy. It takes two to get a dissertation. Thank you for listening when I needed an ear, speaking when I needed a voice, and seeing when I needed vision. I'm grateful and fortunate that we can journey through life, together.

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

There is growing national and international concern for science teacher quality (Howe, 2006). However, recruiting more science and mathematics teachers alone is not enough to address the need for high quality teachers. Those who work with teachers must also realize that the teaching workforce is changing. For instance, science and mathematics teachers have changing patterns of professional persistence, with some reports indicating that 40 to 50% of new mathematics and science teachers leave the classroom in their first three to five years (Cooper & Alvarado, 2006; Ingersoll, 2003; Ingersoll & Perda, 2012).

This revolving door phenomenon (Ingersoll & Strong, 2011) has resulted in a teacher workforce that is comprised of mostly first-year teachers. Whereas in 1988, the most common United States (US) teacher had 15 years of teaching experience, in 2008, the most common US teacher was a first-year beginner (Ingersoll & Merrill, 2012). While there are more beginners in the teaching force, these beginners are less likely to stay teaching as beginners are leaving at the highest rates. With this type of science teacher turnover, it is important to understand the early and formative years of teaching.

Thus, the problem facing science education is one of improving teacher performance as soon as possible in the early formative years. This can translate into crafting teacher preparation and induction programs that support and maximize the learning of early career teachers. Therefore, understanding the experiences and development of early career science teachers is necessary in order to provide helpful support focused on increasing the strength of new science teachers' practices.

Although there is more attention to the population of beginning teachers, the research in this area still faces many challenges. Considering the teacher learning continuum suggested by Feiman-Nemser (2001), some areas are adequately addressed while some are not. For instance, progress has been made regarding the characteristics of effective teacher education, induction, and professional development programs. Teacher education and induction programs with the greatest potential to improve teacher performance, and thus student learning, are those that account for the development of beliefs, practices, and content knowledge (Luft et al., 2011). However, one area that is inadequately addressed is an understanding of how policy impacts early career science teachers' learning and development.

In a teacher education era of policy (Cochran-Smith & Fries, 2005), it is important to understand how policy impacts practice and how practice can inform policy. Much like the dialectical relationship between the global and the local described in Arnove and Torres (2007), there can exist a dialectical relationship between policy and practice. In decentralized nations, control and policy is multi-leveled. At each level, there are policies for teaching and learning. At the micro level, there are classroom and school policies. At the meso level, there are state and regional policies for what is taught and what teachers are expected to know and do. At the macro level, national and international policies such as the United Nations Millennium Development Goals (MDGs) show a unified vision for education and result in similar national policies for beginning teachers worldwide. While such policies all strive to improve teacher quality (Shen et al., 2010), they create educational turbulence (Johnson, 2013) and tensions (Smith &

Southerland, 2007) for teachers. There is a need to better understand how such policies work in tandem or in conflict and what result this has for early career teacher learning and development.

In summary, the teacher workforce in some countries is changing, yet science teacher quality remains an international focus. While more research attention has been given to the population of beginning science teachers, there are many areas in this realm that are not adequately addressed. One area is how micro, meso, and macro policies for teaching and learning influence beginning teachers' learning and development. This dissertation addresses this inadequacy with one empirical study on three US beginning science teachers, one empirical study on twelve US and South African beginning science teachers, and a comprehensive international literature review on newly hired teachers of science over the past 30 years.

Purpose of the Studies

The purpose of this dissertation is to explore the experiences of beginning science teachers, understand how various policies impact practice, and relate how practice can influence policy. Each of the studies are separate and different, yet there is something important with each that helps understand how the various levels of policy influences beginning science teachers and how beginning science teachers' practices can inform policy. The overarching question for the dissertation is "In light of changing policy, how can we better support beginning science teachers to achieve this vision of science teaching that we have for them globally?" The specific objectives for each of the manuscripts include (a) investigating how traveling to different classrooms impacts beginning secondary science teachers' instruction in the US, (b) exploring how national and local policies for beginning teachers are reflected in classroom practice in South Africa and the US, and (c) synthesizing the international research on newly hired teachers of science over the past 30 years.

Background Information

The three manuscripts in this dissertation were part of a larger National Science Foundation (NSF) funded project - Persistent, Enthusiastic, Relentless; Study of Induction Science Teachers (PERSIST). The ultimate goal of this project is to understand the experiences of teachers in the induction years, provide means of support, and understand what beginning teachers learn over time. The grant provided opportunities for research, both nationally and internationally, and led to the research that comprises this dissertation.

The dissertation is presented as a collection of three manuscripts: (1) “Science Teachers Without Classroom of Their Own: A Study of the Phenomenon of Floating”; (2) “Teacher Learning in a Policy Era: A Cross-National Comparative Study of Beginning Science Teachers’ Cycle of Instruction in South Africa and the United States”; and (3) “Newly Hired Teachers of Science: A Review of Research in the Field.” Each of the articles is co-authored. For the first two articles, I was the first author, and in the third manuscript, the literature review, I was the second author. I elected to present the manuscripts in this dissertation in the way in which they were developed. Therefore, the literature review is the third manuscript, rather than the first.

Outline of Each Manuscript

The three manuscripts will contribute to a deeper understanding of the experiences of beginning science teachers locally and globally and have implications for various levels of policy. All three articles help to answer the essential overarching question, “In light of changing policy, how can we better support beginning science teachers to achieve this vision of science teaching that we have for them globally?” Since research on beginning science teachers is emerging, very few studies exist that take a cross-national or international focus. Therefore, Chapters 2, 3, and 4 relate to one another in that each manuscript highlights levels of policy and how policies influence the experiences, successes, and challenges of beginning science teachers.

Chapter 2 examines beginning science teachers in the US and how micro policies influence teaching practice. It specifically investigates how floating among classrooms influences the learning and instructional practices of secondary science teachers and how school context supports or inhibits this learning. It uses cultural historical activity theory (CHAT) as a theoretical and analytical framework to understand components of school context. The results show that school context matters, and floating can either support or inhibit beginning science teacher learning and instruction. Implications are presented for teacher educators, induction specialists, and policy makers.

Chapter 3 considers the learning and experiences of beginning science teachers cross-nationally, in South Africa and the US. In both nations, similarities in policy and curriculum documents show what policy-makers think should occur for science teaching and learning, but little is known about how this influences teachers' instruction. The purpose of this research is to understand how recent trends in globalization in education have shaped the teaching practices and learning experiences of newly qualified teachers. This study uses institutional theory to understand how beginning chemistry teachers in South Africa and the United States engage in an instructional cycle of planning, teaching, and reflection and what constrains or supports their actions in a cycle of instruction. Results show similarities and differences in both countries, and how micro, meso, and macro policies can influence teachers' actions. The implications call for teacher educators and policy makers to consider the influence of changing policies on teacher learning, and how to consider new ways to prepare and support beginning teachers.

Chapter 4 synthesizes the international literature on newly hired teachers of science from 1982 to 2012. The review included 108 research articles over the past 30 years on elementary and secondary science teachers. The review was framed from a macro policy perspective. Specifically, it was focused around the transnational discourses of competencies for beginning teachers. This framework included teacher professional standards from England, Australia, Ontario, New Zealand, and the US. From this examination, six broad areas resulted across the documents that portray the international discourse on teacher learning. These areas are: content and curricular knowledge, professional practice/learning environments, learners and learning, equity, assessment, and professionalism. Each of the 108 research articles was sorted into the area where it most fit. Results show that most of the studies are situated in the US and there are very few studies in the areas of assessment, learners and learning, and equity. The discussion includes future directions for research on newly hired teachers of science and considerations for how to support teachers to meet the global policies that are created to guide teacher education and learning.

In the final chapter, Chapter 5, the three manuscripts are connected to answer the overarching question “In light of changing policy, how can we better support beginning science teachers to achieve this vision of science teaching that we have for them globally?” This chapter presents a synthesis of the contributions of each study in order to better understand beginning teachers’ learning and experiences locally and globally. The policy implications of the manuscripts are also discussed in this final chapter.

References

Arnove, R.F., & Torres, C.A. (2007). *Comparative education: The dialectic of the global and the local* (3rd ed.). Lanham, MD: Rowman & Littlefield.

Cochran-Smith, M., & Fries, K. (2005). Researching teacher education in changing times: Politics and paradigms. In M. Cochran-Smith & K.M. Zeichner (Eds.) *Studying Teacher Education* (pp. 69-109). Mahwah, NJ: Lawrence Erlbaum.

Cooper, J.M., & Alvarado, A. (2006). *Preparation, recruitment, and retention of teachers*. Belgium: The International Academy of Education (IAE). Retrieved January 29, 2014 from http://publications.iiep.unesco.org/Preparation-recruitment-retention-teachers.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record*, *103*(6), 1013-1055.

Howe, E.R. (2006). Exemplary teacher induction: An international review. *Educational philosophy and theory*, *38*(3), 287-297.

Ingersoll, R. M. (2003). Turnover and shortages among science and mathematics teachers in the United States. In Rhoton & Bowers (Eds.), *Science teacher retention: Mentoring and renewal* (pp. 1-12). Arlington, VA: National Science Teachers Association.

Ingersoll, R., & Merrill, E. (2012). *Seven trends: The transformation of the teaching force*. CPRE Working Paper (#WP-01). Philadelphia: Consortium for Policy Research in Education, University of Pennsylvania

Ingersoll, R. & Perda, D. (2012). *How high is teacher turnover and is it a problem?* Philadelphia: Consortium for Policy Research in Education, University of Pennsylvania.

Ingersoll, R.M., & Strong, R. (2011). The impact of induction and mentoring programs for beginning teachers: A critical review of the research. *Review of Educational Research, 81*(2), 201-233.

Johnson, C.C. (2013). Educational turbulence: The influence of macro and micro-policy on science education reform. *Journal of Science Teacher Education, 24*(4), 693-715.

Luft, J.A., Firestone, J., Wong, S., Adams, K., Ortega, I., & Bang, E.J. (2011). Beginning secondary science teacher induction: A two-year mixed methods study. *Journal of Research in Science Teaching*, 48(10), 1199-1224.

Shen, J., Gerard, L., Bowyer, J. (2010). Getting from here to there: The roles of policy makers and principals in increasing science teacher quality. *Journal of Science Teacher Education*, *21*(3), 283-307.

Smith, L. K., & Southerland, S. A. (2007). Reforming practice or modifying reforms?: Elementary teachers' response to the tools of reform, *44*(3), 396–423.

CHAPTER 2

SCIENCE TEACHERS WITHOUT CLASSROOMS OF THEIR OWN: A STUDY OF THE PHENOMENON OF FLOATING[1]

[1] Dubois, S.L., & Luft, J.A. Accepted by the *Journal of Science Teacher Education*. Reprinted here with permission of publisher, 10/10/13

Abstract

"Floating" teachers, or teachers without their own classroom, experience unique affordances and constraints as they develop professionally. To increase the knowledge in this area, this study looks at how traveling to different classrooms impacts beginning secondary science teacher's development and instruction. The participants in this study were three first-year floating secondary science teachers whose experiences were analyzed through a cultural historical activity theory (CHAT) framework. The data revealed how floating can either support or constrain the development of beginning science teachers, and limit the implementation of standards-based instruction. Finally, this study shows that high levels of human, physical, and social resources are necessary for progress towards standards-based science teaching. It suggests that if science teachers must move to different classrooms, then there is a need to create ways in which to support science instruction and science teacher development. Furthermore, it implies that all teachers and supervisors should have a deeper understanding about how the school community impacts the floating science teacher's experience.

Keywords: floating science teachers, CHAT, induction, beginning teachers, teacher development, standards-based science instruction

Introduction

In recent years, classroom space has become an issue in many secondary schools in the United States (US). As a result, there are more classes of students than there are classrooms, forcing some teachers to move to different classrooms for each course they teach. In the case of science teachers, those without a classroom typically travel with all their materials on a cart that has wheels. Sometimes, these teachers ‘float’ into rooms that are not equipped for science teaching. Floating is especially challenging when teachers are trying to achieve the standards recommended by the National Research Council [NRC] for science in science, technology, engineering, and mathematics (STEM) education in the 21^{st} century (NRC, 2011).

There are some studies that report on the floating experience of beginning teachers (e.g., Romano, 2011; Ruschman, 2008; Simmons, 2009). These studies reveal that teachers who are new to the school and school system are often assigned to float between classrooms. As expected, these new teachers are beginning teachers. Unfortunately, these individuals are just building their knowledge and instructional practices. The lack of a designated classroom could impact their professional development, as they are not focused on strengthening and sustaining their knowledge and repertoire (Feiman-Nemser, 2001) but managing and organizing materials.

There is a deficit view of floating in the US. In some countries outside of the US, there is also a deficit view of floating, but it is not uncommon for international teachers to move from classroom to classroom as they enact their instruction. For example, in the widely disseminated Third International Mathematics and Science Study video (https://timssvideo.com/), Japanese teachers moved from classroom to classroom. Unfortunately, there are few studies that look at this phenomenon of moving among classrooms. This descriptive study examined the phenomenon of floating, with the understanding that it is an accepted practice in some countries and not others. In studying three US teachers who were floating in their first year, this study hopes to contribute to the scholarly discussion about this type of assignment as it pertains to beginning secondary science teachers. Using cultural historical activity theory (CHAT), this study specifically explores:

(1) How does floating among classrooms impact the development and instruction of beginning secondary science teachers?; and

(2) What components of school context support or inhibit the development of beginning secondary science teachers who float?

Supporting Literature

Floating Teachers

While there are practitioner-based articles and personal narratives offering tips for the floating teacher (Romano, 2011; Ruschman, 2008; Simmons, 2009), studies that explore the experiences of floating teachers are difficult to find in scholarly journals. Ruschman (2008) and Simmons (2009) provided self-reports of their experiences as floating science and English teachers, respectively. Ruschman (2008) shared his experiences as a veteran teacher who volunteered to be the floating teacher, and ultimately offered advice for floating science teachers. Simmons (2009) recounted her experience as a first-year floating English teacher and highlighted the benefit of receiving unofficial mentoring. While these narrative accounts certainly illuminated this phenomenon, neither article contained any empirical data or findings.

Initial examinations of the literature related to this study revealed four different kinds of floating. One type of floating involves moving to different classrooms around the school. For example, a science teacher may float into a history classroom. A second type of floating consists of moving to different classrooms within the home department. In this situation, a science teacher may only float into other science classrooms. The third type of floating requires a teacher to move between two classrooms with teachers who teach the same subject (e.g., a biology teacher floats into a biology classroom). Typically, these classrooms are close in proximity. A final type of floating consists of changing schools and actually traveling between different sites each day. For example, a chemistry teacher might teach two classes in the morning at one high school and then travel to a second high school to teach two classes in the afternoon. Additionally, related to floating is the situation in which two part-time teachers share a classroom. In this scenario, one teacher may use the classroom in the morning, while the second teacher may use the classroom in the afternoon.

Resources for Standards-Based Science Instruction

In science classrooms, there is an increasing emphasis on instructing in ways that create interactive and student-centered environments that allow for the exploration of natural phenomena (NRC, 1996; NRC, 2012). This type of standards-based science instruction consists of asking questions about phenomena, collecting and analyzing data, making explanations and predictions, and communicating the results of investigations with peers. Science teachers are often responsible for modifying existing curriculum in order to enact lessons that emphasize these skills. However, as Crawford (2000) and Furtak (2006) reported, there are challenges that exist in creating standards-based science classrooms and the implementation of this type of science instruction varies among teachers.

Beginning science teachers face additional challenges when enacting standards-based science instruction in their classrooms. Davis, Petish, and Smithey (2006) determined teachers did not have instructional practices consistent with their notions about standards-based instruction. In studies that specifically examined the instruction of beginning secondary science teachers, Luft (2009) and Luft et al. (2011) found that enacting standards-based instruction depended upon the presence of a science-specific induction program. Secondary science teachers who had access to a robust induction program provided more opportunities for students to engage in directed or guided inquiries. In directed inquiries, the question and mechanism to answer the question is provided by the teacher. In guided inquiries, the question is provided by the teacher but the students answer the question as they see fit. These are in contrast to verification activities where students are told what they will see by following scripted guidelines. Evidence of directed or guided inquiries showed beginning secondary science teachers can enact standards-based science instruction despite first year teaching challenges.

In order to enact standards-based science instruction, Spillane, Diamond, Walker, Halverson, and Jita (2001) found that teachers relied upon human, physical, and social resources. Human resources for science teaching include content knowledge and skills. Physical resources include laboratory tables, sinks, technology, science curricula, science textbooks, consumable supplies and nonconsumable equipment. Social resources include the collaborations and relations among individuals invested in a school science community.

Science education research tends to focus on physical and human resources. In terms of physical resources at the classroom level, Rivera Maulucci (2010) found that a lack of science materials resulted in limited science instruction in three middle school teachers' classrooms. Likewise, Spillane et al. (2001) discovered that additional material resources were necessary for teachers to change their science instruction. However, both researchers emphasized that just a focus on physical resources falls short of improving science instruction. There must be a combined emphasis on human, physical, and social resources as teachers strive to enact standards-based instruction.

In the area of human resources, researchers have investigated the connection between a beginning teacher's content knowledge and science instruction. Smith et al. (2007) examined 744 schools and found a strong association between content-based learning opportunities and standards-based science instruction. This indicated that increased content knowledge was positively related with standards-based instruction. Similarly, Kanter and Konstantopoulos (2010) also reported that teacher content knowledge was a determining factor in the implementation of standards-based science instruction and student achievement. Additional researchers have shown that content-based professional development was positively connected to student learning in science (e.g., Banilower, Heck, & Weiss, 2007; Johnson, Kahle, & Fargo, 2007), which reinforces the important role of content knowledge during science instruction.

Research on the impact of social resources on science instruction is emerging. The importance of educative support as teachers navigate and create standards-based learning environments was evident in Bianchini, Johnston, Oram, and Cavazos (2003), Crawford (2000), Rivera Maulucci (2010), and Roehrig, Kruse, and Kern (2007). These studies revealed the importance of colleagues and the school environment in supporting the implementation of standards-based science instruction. However, Little (2003) suggested that while a professional community was an important contributor to teacher development, it could also hinder opportunities for teacher learning and practice. That is, a professional community guides teachers towards established instructional school norms. Most of the research in this area, however, focuses on experienced teachers.

There is a need to understand how resources impact new teachers as they strive to enact standards-based instruction. New teachers have different instructional needs than experienced teachers, which results in a different use of resources (Feiman-Nemser, 2001; Luft, Neakrase, Adams, Firestone, & Bang, 2010). In Luft et al. (2010), there was discussion of early career science teacher development that suggested central tasks associated with preservice, induction and professional development programs. Some of these tasks included building content knowledge, expanding instructional practice, and learning about students. By engaging in coordinated central tasks, they suggested new science teachers can sustain and increase their effectiveness. This is particularly important for new science teachers in challenging contexts (i.e. without a classroom), as these teachers need the most support as they are learning to teach.

Context

Most researchers agree that context matters in teacher learning and development, and that context is more than a physical setting with combinations of people. Erickson and Schultz (1997) examined individual's words and actions in different situations and determined that "contexts are constituted by what people are doing and where and when they are doing it" (p. 22). The interactions of these components are the contextual environment. Thus, ideas, views, rules, divisions of labor, and resource availability are major constituents of context.

Grossman (1990), in her model of teacher knowledge, emphasized the importance of school context in enacted teacher knowledge. In particular, she suggested that teachers must adapt their more general knowledge to their school contexts. Cochran-Smith and Zeichner (2005) stated a need for frameworks of teacher development that examine how teaching is influenced by contexts, materials, and people. In science education, Davis, Petish, and Smithey (2006) and Davis and Smithey (2009) concluded it is necessary to understand the influential variations in school and classroom contexts on science teacher development. Clearly, researchers acknowledge the role of context in various aspects of teacher development.

Researchers have emphasized that context is of the utmost importance to beginning teachers (Gold, 1996; Wang, Odell, & Clift, 2010). For beginning science teachers, context may be negotiated by an induction program (Ingersoll & Strong, 2011; Luft et al., 2011) or a coherent preservice and induction program (Luft, 2009). However, these studies are recent and there is a need for additional research in the area of context and beginning science teachers (Wang, Odell, & Schwille, 2008). Since school context shapes both teacher instruction and career decisions (Cochran-Smith et al., 2012), it is necessary to understand context in order to best support beginning science teachers in their specific school settings.

Theoretical and Analytical Framework

CHAT (Engeström 1987, 1999, 2001) is this study's theoretical and analytical framework. CHAT is an ideal framework because of the emphasis on teaching context, the limited number of participants, and the importance of standards-based instruction. Using the CHAT components allows cross-case analysis of context in different activity systems.

CHAT is composed of several parts, and Figure 1 represents the activity system components in this study. The *subject* is the individual whose actions are being studied. In this study, the subject is each individual floating science teacher. The *object* is the motivation or goal of the subject. In this study, the object is to implement standards-based science teaching. The *outcome* is the reasoning behind the object. For example, the outcome is that standards-based science teaching enhances student learning. The *tools* of the system are the mediating artifacts that help the subject accomplish the object. The cognitive tools are the human resources, such as the knowledge and skills used to teach standards-based science. The physical tools are the material resources, such as classrooms and equipment. The *community* of the activity system consists of the individuals or groups who have some stake in the object of the activity system.

The community comprises the social resources and includes members of the induction program, colleagues, host teachers, and principals.

The *division of labor* can be considered both horizontally and vertically. Horizontally, it refers to how tasks are divided amongst members of the community, and vertically it means the division of power and status. The horizontal division of labor is the amount of work each individual is doing to accomplish the object. The vertical division of labor can be considered top down, from principals to administrators, to department heads, to host teachers, to floating teachers. A hierarchy is created in terms of power, and the floating teachers are at the bottom. The *rules* of the activity system are the regulations, norms, or conventions that govern the activity system. The rules are the logistical rules of the school and the rules of teaching standards-based science.

Overall, the *subject* uses *tools* to accomplish an *object* that is justified by an *outcome*. These components exist in a *community* which has *rules* and *divisions of labor*, all of which interact to create the activity system. In the current study, floating first-year science teachers use human and physical resources in order to implement standards-based science teaching. Additionally, these components exist dialectically with the social resources of a community of individuals who determine and enact rules and divisions of labor. The purpose of this study is to understand the experiences of floating first-year science teachers by using CHAT to determine how context impacts the development and instruction of first-year floating science teachers.

Methods

Design

In building an understanding about the experiences of floating science teachers, this study drew upon traditional qualitative methods and the CHAT framework. The qualitative methods in this study are based on those described by Merriam (2009), and included inductively coding the different forms of data. When the data sources were coded, the researchers examined the codes within the CHAT framework. The participants were compared to one another to clarify cross-cutting ideas.

Context & Participants

The study consists of three first-year secondary science teachers in urban high schools in the West and Southwest US. The participants are referred to by pseudonyms. Elvira taught chemistry and physical science in a school that had few students who received free or reduced lunch (an indicator of poverty in the US). James taught physical science and life science in a school with about 45% of the students receiving free or reduced lunch. Candice taught life science, and most of her students participated in a free or reduced lunch program. All three participants held bachelor’s degrees in a science discipline. Elvira and James were certified in their fields, and held Master’s degrees in education. Candice was in an alternative certification program that would award her a Master’s degree at the end of her first-year of teaching.

The participants were selected because they were floating as first-year secondary science teachers, they taught high school, they had a complete data set for the first-year, they could be located, and they agreed to participate in follow-up conversations about their first-year experiences. This aligns with purposeful sampling because it identifies individuals based on the specific research focus and questions (Henry, 1990).

As first-year teachers, Elvira and James participated in a science-specific induction program, which provided them additional support in terms of implementing standards-based science instruction. The alternative certification program in which Candice was enrolled provided her with general support during her first year. For additional details, see Luft (2009).

Data Collection

At the beginning of the study, prior to the first day of teaching, demographic information was collected from each teacher, as were their expectations for the upcoming years. At the conclusion of their first school year, teachers were interviewed about their teaching experiences, the impact of support they did or did not receive as a beginning science teacher, and any important circumstances they had over the year (e.g., like floating). These interviews allowed participants to summarize their experiences over the course of the year, the support they received, and the challenges they encountered. Additionally, these general interviews provided background and supporting information pertaining to the beginning secondary science teachers.

The second form of data focused entirely on classroom instruction. This instruction was captured by observations and interviews throughout the teachers' first year. The observations of teachers were conducted four times during the school year, during a specific two-week period of time. During an observation the classroom instruction was coded in five-minute increments, following the Collaboratives for Excellence in Teacher Preparation core evaluation classroom observation protocol, which was piloted, field-tested and refined by Lawrenz, Huffman, Appeldoorn and Sun (2002), and Appeldoorn (2004) to document the instruction of science and mathematics teachers. It includes aspects of the Horizon Research Observational Protocol that was developed for use in the National Science Foundation Local Systemic Change program (see Banilower, Boyd, Pasley & Weiss, 2006). This protocol was modified in order to document investigations that were guided, directed, or verification oriented. Proccess/skill focused investigations were also documented, and these types of investigations did not focus on a concept. Instead, they addressed learning a laboratory skill (e.g., pipetting, titration) or a process skill (e.g., observation, inference). In addition, field notes were made during the observation to support the coding of each teacher's instruction. Inter rater consistency was established prior to observing classrooms.

Interviews about practice captured a week of classroom instruction and experiences as new science teachers. This interview matched the observational protocol by Lawrenz, et al. (2002). As the teacher reported his or her instruction, the occurrence of the instruction (e.g., guided inquiry, directed inquiry, verification activity, process/skill lesson) was indicated on a scoring sheet. The remaining questions focused on the school and classroom experiences of the new teachers, the support they were using and desired, and other areas of personal importance. Interviews were conducted each month for eight months during the school year for a total of eight interviews per year. The interviews lasted approximately 30-60 minutes. Prior to using this protocol to document instruction, inter rater consistency was established. Detailed descriptions about the collection of instructional data and the interviews can be found in Luft (2009).

The final form of data was a follow-up interview conducted seven years after initial interviews and observations with the three study participants. The purpose of this interview was to gain specific insights into the floating science teachers' experiences after several years. This semi-structure interview followed guidelines suggested by Bogdan and Biklen (2006) and provided participants with an opportunity reflect on teaching without a classroom. Some questions in the follow-up interview included: (1) Tell me about your experience as a floating science teacher; (2) Do you think floating impacted how you taught science? If so, how?; and (3) Do you think floating affected your change as a teacher over time? If so, how?

During the interviews, different researchers talked to different teachers, which contributed to the triangulation of data (Seidman, 1998). The interviewers were non-judgmental throughout the process, they sought to understand the beginning teachers, and they often probed for specifics related to their professional development. The interviews followed guidelines by Bogdan and Biklen (2006). This contributed to the validity of the information shared by the beginning secondary science teachers, while the developed format for the interviews contributed to the reliability of the interview process (Kirk & Miller, 1986).

Data Analysis

All observations, documents, and interviews were uploaded into NVivo software for management and analysis. Each participant had an individual folder with specific documents. The first round of coding followed Bodgan and Biklen (2006), and captured the participant's main ideas and salient experiences. Some of the codes consisted of: receiving assistance from the host teacher, lacking ownership, sharing materials, and finding it challenging to set up labs. The codes that emerged were organized by the authors into the CHAT categories (subject, object, outcomes, rules, tools, community, and division of labor) and by participant. For instance, sharing materials was the code used when a participant specifically noted that a host teacher left a laboratory in place for further use, or allowed the participant to use physical classroom resources such as white boards or stationary supplies. The sharing material code was then moved into the CHAT category of community because it involved host teachers or colleagues.

Linking the codes to both participant and category allowed the authors to make sense of individual activity systems, as well as compare activity systems. This aligns with third generation activity theory (Engeström, 2001). Coding was cross-checked by both researchers, and if disagreement arose, discussion would occur until consensus was reached.

Portraying participants in individual CHAT activity systems ultimately allowed for a comparison among participants in order to identify descriptive patterns. When comparing participants to one another, Miles and Huberman's (1994) discussion of cross-case analysis was followed during the analysis process. The cross-case analysis produced identified patterns, consisting of similarities and differences among the participants. This approach highlighted individual differences, while also enriching the researchers' understanding of the experiences of floating science teachers.

Results

Candice's Activity System

Candice taught life science in two different classrooms that were three doors away from each other. She shared rooms with teachers who were teaching the same science content, and elected to have her personal desk space in the classroom where she taught most of her classes. Her physical resource *tools* were abundant as both of the classrooms were built for laboratories and contained sinks, laboratory counters, glassware, and other supplies.

Candice's *community* was supportive and helpful, but her host teachers acknowledged they would not want to float themselves. Even in this setting, the social resources at her school were adequate, as she had a positive relationship with her host teachers who encouraged and promoted sharing science materials. At times, the teachers would leave the laboratory set-up for Candice's use. In addition, the host teachers were always around to provide needed advice or assistance with the laboratory. The affordances of sharing a room with other science teachers became clear to Candice early in the year, when she was initially assigned to share a classroom with a mathematics teacher who rarely provided assistance. Through experience, she learned it was challenging to share a non-science classroom with a non-science teacher. Candice's view of her community experiences is illustrated when she stated:

> …you know, we share materials. So much that it kind of made it easier... Now, I would say if you're not teaching the same class, then that's a little bit more difficult. For that

> time when I was in a non-science classroom…everything was just wrong. But, I would say sharing a science classroom with a science teacher really wasn't that big of a deal [Interview, July 2012].

In Candice's *division of labor*, she worked hard and used the opportunity to learn from colleagues. She saw having another teacher in the room a positive asset because it provided her more assistance and did not make her nervous when she was observed by administrators, or other teachers. However, it did create an unintended hierarchy between the host teacher and herself. She often felt as if she was a student teacher in this setting. Candice, however, did not see this as a negative situation since her own alternative certification route to teaching did not consist of a traditional student teaching experience.

Although the *rules* were less prevalent in Candice's activity system, it was evident that she followed them. It was the rule at her school that first-year teachers would be the ones who floated, and she willingly agreed to this assignment. However, even these rules were flexible since she was able to change classrooms early in the year after she discovered she was sharing a classroom with a non-science teacher.

In terms of the *object* of implementing standards-based science teaching, Candice enacted instruction that was the norm at her school. According to observational data, this was not a school that espoused standards-based science instruction. For example, Candice was often observed going over vocabulary words with students or giving direct instructions (field notes, January 2006 and February 2006). When she tried to have students complete a simulation on DNA transcription and translation, the students were confused without direct instructions (field notes, May 2006). If the lessons included components of standards-based instruction, they were often verification activities. For example, in one lesson students measured paper bones of the human body and placed them in a replica of the human body by copying what the teacher had on the board (field notes, November 2005). Candice admitted she never felt constrained to implement an inquiry lesson or laboratory, which was a reflection of her internalization of the school's accepted degree of standards-based instruction. That is, she remained confident in the science teaching she practiced in her classrooms because her host teachers supported her in enacting their degree of standards-based science instruction.

Each of these components impacted the *subject*, Candice. Ultimately, she thought there were more benefits than constraints to being a first-year floating science teacher. Some of these benefits included the sharing of materials, and receiving assistance pertaining to instruction. However, despite her positive view of floating, in a follow-up interview after her first year she acknowledged that floating was a limited duration experience and she looked forward to having her own classroom.

Elvira's Activity System

Throughout her first-year of teaching, Elvira taught earth science and chemistry in three different classrooms. Only one of the classrooms was not equipped for teaching science, and this was a challenge in terms of setting up laboratories. Going between classrooms required her to utilize a cart that contained physical resource *tools* such as her computer, lab materials, and textbooks. To keep herself organized, she kept personal and relevant materials close at hand and often on her cart.

The *division of labor* was a predominant area in Elvira's first year, as she often had to work harder than her colleagues. For example, in planning for a laboratory, Elvira was often not synchronized with her colleagues and, as a result, had to individually collect materials and set-up and break down the laboratory in each classroom. Furthermore, when she wanted to enact laboratories during all of her classes, she had to find another teacher who would be willing to switch classrooms with her for the entire day. When this did not happen (which was often), she had to collect the materials needed to conduct the laboratories and place these on her cart. The following excerpt illustrates Elvira's nomadic experience:

> Instead of just staying in one classroom all day, where you can really just set up the lab and just have your kids come in and move through the stations, I felt like I was setting up and picking up labs all day long [Interview, July 2012].

Despite this situation, Elvira worked relentlessly to conduct laboratories in her classrooms. Her commitment to laboratory instruction emerged from her own valuable experiences with laboratories, her teacher preparation program, and her induction program. These various prior and current experiences contributed to her human resource *tools* to teach standards-based science. During interviews, she often provided examples from her preparation program and her induction program that supported the type of laboratories and experiences she implemented for her students to explore.

In terms of her social resources and *community*, Elvira was not always supported to enact standards-based science teaching. For instance, she shared a room with one teacher who was very particular about his white board. Elvira was not allowed to erase his drawings or notes, and there was rarely space for her to write necessary information. Even when she requested space, he would still not leave space-- so she was forced to erase some of his text in order to write her own notes or instructions. However, her other colleagues tried to accommodate her instructional needs and provided her with space on the white board, and left materials out that she might find useful. Additionally, her induction program provided science-specific support. Overall, Elvira's community was both supportive and constraining as she taught her first year.

The *rules* that impacted Elvira were unspoken, yet impacted her instruction. Among Elvira's host teachers there was an unspoken rule that the materials in the classroom belonged to them, and that nothing in the classroom belonged to her. A related consequence of floating and to the *rules* was that Elvira was not able to establish any rules or routines for her students in terms of where to turn in assignments or where to find her throughout the day. She highlighted this in the following interview excerpt:

> You know instead of saying, "You will always find what you need over here on this side of the room..." It was more like, "OK, I've lost this paper and you'll have to come back in… and where can you find me? Oh, you'll have to find me, let's see, in this classroom -- you know in this period" [Interview, July 2012].

Elvira's *object* of standards-based science teaching was impacted by her floating experience. During observations, Elvira demonstrated components of standards-based lessons. For example, in her chemistry class Elvira arranged for students to do a directed inquiry alloy lab (field notes, February 2006). However, when asked about her instruction, Elvira often explained that she modified or skipped laboratories to align with the school culture. For instance, sometimes she would do simple demonstrations in place of a laboratory, as students needed to complete their laboratories in one day to prevent the apparatus from residing in a classroom that she was not in all day. Elvira illustrated her struggles with laboratories in this excerpt:

> I think a lot of the times labs get skipped and things get skipped because you don't have the time… I mean, it's not like I could stay after … and kids could stay all day. … Everything was really simple and… very basic because of the fact that I had 7 minutes to pack up and get to the next classroom and get set up again [Interview, July 2012].

As a *subject*, Elvira really worked with the challenge of being a floating first-year science teacher. She modified labs and would even set up simple laboratories just to allow her students to experience ‘science.’ She acknowledged that from the floating experience she had to be more prepared and organized than her non-floating peers. In many of her classroom instruction interviews, the idea of having to be organized was salient. However, even with the positive view of floating, the struggle of being a floating science teacher outweighed the opportunity. She lacked storage places in classrooms, she did forget things, students had a hard time finding her, there was no classroom routine, she had to modify or skip labs, and she had some challenges with the host teachers. When Elvira was no longer a floating teacher, she stated:

> I’m excited that I have my own classroom… again, the most frustrating thing was the fact that I did move around... The fact that it was ‘our’ classroom, but nothing in there belonged to me. And there was no central place. I had a crate where kids could find things, but I had to tote that crate around with me. And, you know, that was frustrating. I think I’m more excited to have my own place [Interview, June 2006].

James’ Activity System

James floated into seven different classrooms his first-year of teaching. In his school, these classrooms were in different buildings and on different floors. He kept his class materials on a cart that he pushed around the school, but his personal materials were kept on his desk space in the teacher workroom. Some of the classrooms in which he taught were science classrooms, while other classrooms were regular classrooms that did not have equipment or textbooks for science teaching. As a result, his physical resource *tools* in his non-science classrooms were limited; however, his human resource *tools* were well-developed and similar to Elvira’s in terms of content knowledge, and preservice coursework.

In terms of the social resources in his *community,* James considered his host teachers to be extremely supportive. They were unofficial mentors who provided him with occasional tips on classroom management and helped him learn organizational skills. He often described his host teachers as understanding and helpful. Furthermore, his science-specific induction program provided him with additional content support. He valued having observations by the induction program staff, as their feedback reminded him how to teach science.

The *divisions of labor* were prevalent in James' position as a floating science teacher. In each of his classrooms, he did not feel ownership of the space or materials. Even though his host teachers were accommodating, there were rules about not moving existing materials or bringing in too many new materials into the classroom. Additionally, many times, he was in a similar position of power as the students because he showed up to the classroom as the bell was ringing. The expectation at the school was for the teacher to be standing at the door to greet students when they arrived, and this was difficult for James and his cart.

In James' system, *rules* took on dual meaning. The guidelines of his science-specific induction community focused on how to implement standards-based science teaching, while the enactment of rules within his classroom focused on organization and procedure. He found it difficult to attain both sets of rules in addition to the variations of classroom spaces he experienced daily. His reflection on classroom rules was highlighted by the following excerpt:

> Then also nobody ever really talked about how to start a class with implementing procedures and rules and how to get those things off the ground… that's kind of one of the things I'm focusing on now for my classes… how I'm going to be doing those things [Interview, August 2006].

For the *object* of standards-based science teaching, observations of James' instruction indicated that he attempted to implement some standards-based science teaching despite his challenging circumstances. For example, in one observation, James had students do a directed inquiry dissolving Tums in two different water temperatures. The students came up with a hypothesis, collected and graphed data, and determined a conclusion (field notes, December 2005). Although James indicated that setting up laboratories was difficult not having his own classroom, he was uncertain how many more laboratories he would have tried to enact even if he did have his own classroom. He often found the most significant constraint in implementing the laboratories to be engaging the students in the laboratory activity.

Each of these CHAT components impacted the *subject*, James, who ultimately indicated that being a floating science teacher was challenging. He found few benefits to the experience and believed it stunted his development as a teacher. James summarized his thoughts on being a floating science teacher in the following excerpt:

> I don't think that I've ever heard a single good thing about teachers floating from anyone. And then my experiences - there was nothing positive about changing rooms…I think it only makes things difficult and it causes potential conflicts between other teachers [Interview, July 2012].

Activity Systems Summary

CHAT highlighted the coherence or contradictions in the activity systems. While each component of the framework impacted the beginning science teacher, an overall synthesis of the activity systems specifically emphasized coherence or contradictions between (1) the *subject* and the *community*; and (2) the *subject* and the *object*.

For the relationship between the *subject* and the *community,* the social resources of the community played an important role in the experience of the first-year floating science teacher. In Candice's system, there was strong coherence between the community and the subject. However, for Elvira and James, there were contradictions between the *community* and *subject*. For James, having non-science host teachers and non-science classrooms created tensions in the learning environments he tried to create. For Elvira, trying to find a permanent classroom for a day when she wanted to do a laboratory was problematic because her colleagues often did not want to give up their classroom spaces and float for a day.

The second relationship that was prevalent from the activity systems was between *subject* and *object*. The *tools* became important human and physical resources in this relationship and the delineation between human and physical resources was crucial. Elvira and James had sophisticated human resources, while Candice had less developed human resources. However, in terms of physical resources, the opposite situation occurred. Candice had the physical classroom resources readily available for teaching standards-based science, whereas James and Elvira lacked the physical resources to enact standards-based science lessons in every classroom.

There are two explanations to describe the relationship between *subject* and *object*. In Candice's system, there was strong coherence between the subject and object, and she did not feel constrained or limited to implement a lesson or a laboratory although her implementation was often verification oriented. In contrast, Elvira and James experienced contradictions between *subject* and *object*, and were unable to implement standards-based instruction to their fullest potential due to the context of their classrooms and schools. Regardless of the socioeconomic settings of their schools, the participants had less implementation of standards-based instruction.

Discussion

The first question in this study asked how floating among classrooms impacted the development and instruction of beginning secondary science teachers. The individual and cross-cutting analysis of the participant's activity systems revealed that teachers were impacted by floating in several ways. Specifically, floating was either an affordance or a constraint to their development. For a teacher like Candice, who had an activity system in equilibrium, the experience was an affordance to her development as a science teacher. She had a supportive *community*, equitable *divisions of labor*, and readily available physical resource *tools* in each classroom. However, for Elvira and James, the experience was a constraint to development. The *community* was not entirely supportive, the *division of labor* was not equitable, and the physical resource *tools* were not available in each classroom.

Another finding related to the first question pertains to the relationship of floating to standards-based science instruction (the *object*). Overall, none of the participants' excelled in implementing standards-based instruction, which is in agreement with previous research on the difficulties new teachers face enacting standards-based instruction (Crawford, 2000; Furtak, 2006). However, observational data show that floating did limit the standards-based instruction of the teachers. Elvira and James had advanced education degrees and good science knowledge, factors which are connected to standards-based science teaching (Kanter & Konstantopoulos, 2010; Smith et al., 2007). Yet the task of moving from room to room often impacted the guided or directed inquiry instruction they wanted to enact, and ultimately limited their opportunities to build foundational skills and knowledge in teaching standards-based science.

These findings reinforce the important role of context as a teacher is learning to teach (Cochran-Smith & Zeichner, 2005). While it is generally known that new science teachers are impacted by their context (Luft et al., 2011), there has not been a model to explain the interface between context and development. In this small study, these two positions suggest that CHAT components may contribute or impede teacher instruction and development. It is not clear if all components need to be present, or if they are weighted so that some may be more significant than others – but these are potentially important areas to consider when working with beginning science teachers. This variation also suggests that new science teachers have pliable instruction as they are learning to teach, but this has been reported by other researchers (Luft et al., 2011).

The second question in this study sought to understand which components of school context supported or inhibited the development of beginning secondary science teachers who floated. This question actually expands upon the findings of the first question, and provides important insights in this area of context. For this question, the concepts of human, social, and physical capital (Bourdieu, 1986) help describe the components of school context that support or inhibit teacher development.

In this study, Elvira and James had had less physical capital in the form of material resources, and high human capital in the form of science teaching knowledge. Their social capital was high in the area of science-specific induction support, and low because they did not always have a supportive community. Candice, on the other hand, had physical capital in the form of material resources in her classrooms, but less human capital in the form of knowledge to teach in standards-based ways. She also had social capital that was low and high. She had high social capital in the form of support from science teachers in her department, but she had low social capital from her general induction program that lacked a science-specific focus.

Each participant was lacking multiple components of the necessary capital, which hindered the full implementation of standards-based science instruction. Teachers rely on activating these forms of capital in their teaching experiences, and there is some combination of these resources that is necessary for standards-based science teaching (Rivera Maulucci, 2010; Spillane et al., 2001). This research expands on the importance of social resources or capital in science teaching. It highlights that social capital in the form of supportive communities is not necessarily enough to enact standards-based science teaching. If the school community has a lower standard for standards-based science teaching, then community support alone will not assist in the development of human capital for a beginning science teacher. This supports Little (2003) who cautioned that social resources can either open up or hinder teacher development.

Implications

Based on this study, there are four recommendations. First, administrators should consider science teacher location. If a US science teacher must travel to multiple rooms, then school administrators should ensure that these rooms have host teachers who teach the same science subject and are equipped for science teaching. It suggests that floating into rooms with teachers who teach the same content in standards-based ways creates equilibrium with few contradictions in the activity system.

Secondly, when investigating beginning science teacher development, the interaction of various human, physical, and social resources must be considered. When one or more forms of such capital are lacking, development and progress towards standards-based science teaching are hindered. For instance, having high levels of human resources to teach in standards-based ways is not enough without physical and social resources to do so. Likewise, having high levels of physical and social resources without human resources also limits standards-based instruction.

Third, it is recommended that all teachers, administrators, and supervisors have a deeper understanding of the floating science teacher's experience. For example, when it comes to observing teachers, administrators and supervisors should know that it is more difficult for floating science teachers to implement guided or directed inquiries. Colleagues and host teachers should be aware they are important social resources for the floating teacher. It is clear from this study that the host-floating teacher relationship can be a type of unofficial mentoring accelerating or hindering new teacher development. Teachers who are host teachers should willingly share their classroom space and provide advice or assistance when appropriate.

Finally, as the science education community promotes standards-based science instruction, it is important to consider how new science teachers are best prepared to support their vision. Emphasizing practices, such as those that are in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012), in preservice and induction programs may reduce the oscillation of instruction among new teachers. In addition, supporting the development and enactment of science-specific induction programs is important. The teachers in this study who participated in science-specific induction programs made more attempts at standards-based teaching --even without as many material resources available.

In conclusion, more research is needed in the area of floating as it pertains to science teacher development. In particular, future research could examine how sharing classrooms or how traveling to different school sites impacts beginning science teacher development. Also, the dialectical relationship between school context and teacher development could be further examined. Finally, future research could investigate the interaction of various resources in the contextualized development of the beginning science teacher.

Acknowledgements

The authors of this study would like to acknowledge Gillian Roehrig who assisted with the data collection in this study, and the teachers who participated enthusiastically in the interviews and observations. This study was made possible by National Science Foundation grants 0550847, 0918697, 0732600, and 0632368. It was also made possible by the University of Georgia Graduate School scholarship that supported the time of the first author. The findings, conclusions, or opinions herein represent the views of the authors and do not necessarily represent the view of personnel affiliated with the National Science Foundation or the Graduate School at the University of Georgia.

References

Appeldoorn, K. (2004). Developing and validating the Collaboratives for Excellence in Teacher Preparation (CETP) core evaluation classroom observation protocol (COP). PhD dissertation, University of Minnesota, Minneapolis, MN.

Banilower, E. R., Boyd, S. E., Pasley, J. D., & Weiss, I. R. (2006). Lessons from a decade of mathematics and science reform: A capstone report for the Local Systemic Change through Teacher Enhancement Initiative. Chapel Hill, NC: Horizon Research, Inc.

Banilower, E.R., Heck, D.J.,& Weiss, I.R. (2007). Can professional development make the vision of the standards a reality? The impact of the national science foundation's local systemic change through teacher enhancement initiative. *Journal of Research in Science Teaching, 44*(3), 375–395.

Bianchini, J.A., Johnston, C.C., Oram, S.Y., & Cavazos, L.M. (2003). Learning to teaching science in contemporary and equitable ways: The successes and struggles of first-year science teachers. *Science Education, 87*, 419-443.

Bogdan, R. C., & Biklen, S. (2006). *Qualitative research for education: An introduction to theory and methods*. Needham Heights, MA: Allyn & Bacon.

Bourdieu, P. (1986). The forms of capital. In J.G. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241-258). New York: Greenwood.

Cochran-Smith, M. & Zeichner, K.M. (2005). *Studying Teacher Education: The Report of the AERA Panel on Research and Teacher Education.* Mahwah, NJ: Lawrence Erlbaum Associates.

Cochran-Smith, M., McQuillan, P., Mitchell, K., Terrell, D.G., Barnatt, G., D'Souza, L., Jong, C., Shakman, K., Lam, K., & Gleeson, A.M. (2012). A longitudinal student of teaching practice and early career decisions: A cautionary tale. *American Educational Research Journal, 49*(5), 844-880.

Crawford, B. A. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching*, *37*(9), 916–937.

Davis, E.A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research*, *76*, 607–651.

Davis, E.A., & Smithey, J. (2009). Beginning teachers moving toward effective elementary science teaching. *Science Education*, *93,* 745-770.

Engeström, Y. (1987). Learning by expanding: An activity–theoretical approach to developmental research. Laboratory of Comparative Human Cognition. http://lchc.ucsd.edu/mca/Paper/Engestrom/expanding/toc.htm

Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engström, R. Miettinen, & R.L. Punamäki (Eds.), *Perspectives on Activity Theory* (pp. 19-38). Cambridge, UK: Cambridge University.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work*, *14*(1), 133–161.

Erickson, F. & Schultz, J. (1997). When is a context? Some issues and methods in the analysis of social competence. In M. Cole, Y. Engeström, & O. Vasquez (Eds.), *Mind, Culture, and Activity* (pp. 22-31). Cambridge, UK: Cambridge University.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103*(6), 1013-1055.

Furtak, E. M. (2006). The problem with answers: An exploration of guided scientific inquiry teaching. *Science Education, 90*, 453-467.

Gold, Y. (1996). Beginning teacher support: Attrition, mentoring, and induction. In J. Sikula (Ed.), *Handbook of research on teacher education* (pp. 548–594). New York: Macmillan.

Grossman, P.L. (1990). *The Making of a Teacher: Teacher Knowledge and Teacher Education*. NY: Teachers' College Press.

Henry, G. T. (1990). *Practical sampling.* Newbury Park, CA: Sage.

Ingersoll, R.M., & Strong, R. (2011). The impact of induction and mentoring programs for beginning teachers: A critical review of the research. *Review of Educational Research, 81*(2), 201-233.

Johnson, C.C., Kahle, J.B., & Fargo, J.D. (2007). A study of the effect of sustained, whole-school professional development on student achievement in science. *Journal of Research in Science Teaching*, *44*(6), 775–786.

Kanter, D.E. & Konstantopoulos, S. (2010). The impact of a project-based science curriculum on minority student achievement, attitudes, and careers: The effects of teacher content and pedagogical content knowledge and inquiry-based practices. *Science Education, 94*, 855-887.

Kirk, J. & Miller, M. L. (1986). *Reliability and validity in qualitative research*. Newbury Park, CA: Sage.

Lawrenz, F., Huffman, D., Appeldoorn, K., & Sun, T. (2002). *CETP core evaluation, classroom observation handbook.* Minneapolis, MN: CAREI.

Little, J.W. (2003). Inside teacher community: Representations of classroom practice. *Teachers College Record*, *105*(6), 913-945.

Luft, J .A. (2009). Beginning secondary science teachers in different induction programs: The first year of teaching. *International Journal of Science Education, 31*(17), 2355-2384.

Luft, J.A., Firestone, J., Wong, S., Adams, K., Ortega, I., & Bang, E.J. (2011). Beginning secondary science teacher induction: A two-year mixed methods study. *Journal of Research in Science Teaching,* 48(10), 1199-1224.

Luft, J.A., Neakrase, J., Adams, K., Firestone, J., & Bang. E. J. (2010). Bringing content into induction programs: Examples from science. In J. Wang, S. Odell, & R. Cliff (Eds.), *Past, present, and future research on teacher induction: An anthology for researchers, policy makers, and practitioners* (pp. 205-220). Lanham, Maryland: Rowman & Littlefield Education.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Jossey-Bass.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis. Thousand Oaks, CA: Sage.

National Research Council. (1996). National science education standards. Washington, DC: National Academy Press.

National Research Council. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics.* National Academies. Retrieved from http://www.nap.edu/catalog.php?record_id=13158.

National Research Council. (2012). *A Framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academy Press.

Rivera Maulucci, M.S. (2010). Resisting the marginalization of science in an urban school: Coactivating social, cultural, material, and strategic resources. *Journal of Research in Science Teaching, 47*(7), 840-860.

Roehrig, G.H., Kruse, R.A., & Kern, A. (2007). Teacher and school characteristics and their influence on curriculum implementation. *Journal of Research in Science Teaching, 44*(7), 883–907.

Romano, M. (2011). Homeless not hopeless: Tips for the traveling teacher. *The Science Teacher, 78*(1), 14-14.

Ruschman, R. (2008). Tips for the travelings teacher. *The Science Teacher, 75*(6), 50-53.

Seidman, I. (1998). *Interviewing as qualitative research*. New York: Teachers College Press.

Simmons, A.M. (2009). A room of one's own: The accidental mentoring of a traveling teacher, *English Journal, 98*(3), 110-112.

Smith, T., Desimone, L., Zeidner, T. L., Dunn, A. C., Bhatt, M., & Rumyantseva, N. L. (2007). Inquiry-oriented instruction in science: Who teaches that way? *Educational Evaluation and Policy Analysis*, *29* (3), 169-199.

Spillane, J.P., Diamond, J.B., Walker, L.J., Halverson, R., & Jita, L. (2001). Urban school leadership for elementary science instruction: Identifying and activating resources in an undervalued school subject. *Journal of Research in Science Teaching, 38*(8), 918-940.

Third International Mathematics and Science Study video. (n.d.). Retrieved January 3, 2013 from the TIMSS video: http://timssvideo.com/

Wang, J., Odell, S., & Clift, R. (2010). *Past, Present, and Future Research on Teacher Induction: An anthology for researchers, policy makers, and practitioners.* Lanham, Maryland: Rowman & Littlefield Education.

Wang, J., Odell, S.J., & Schwille, S.A. (2008). Effects of teacher induction on beginning teachers' teaching: A critical review of the literature. *Journal of Teacher Education, 59*(2), 132-152.

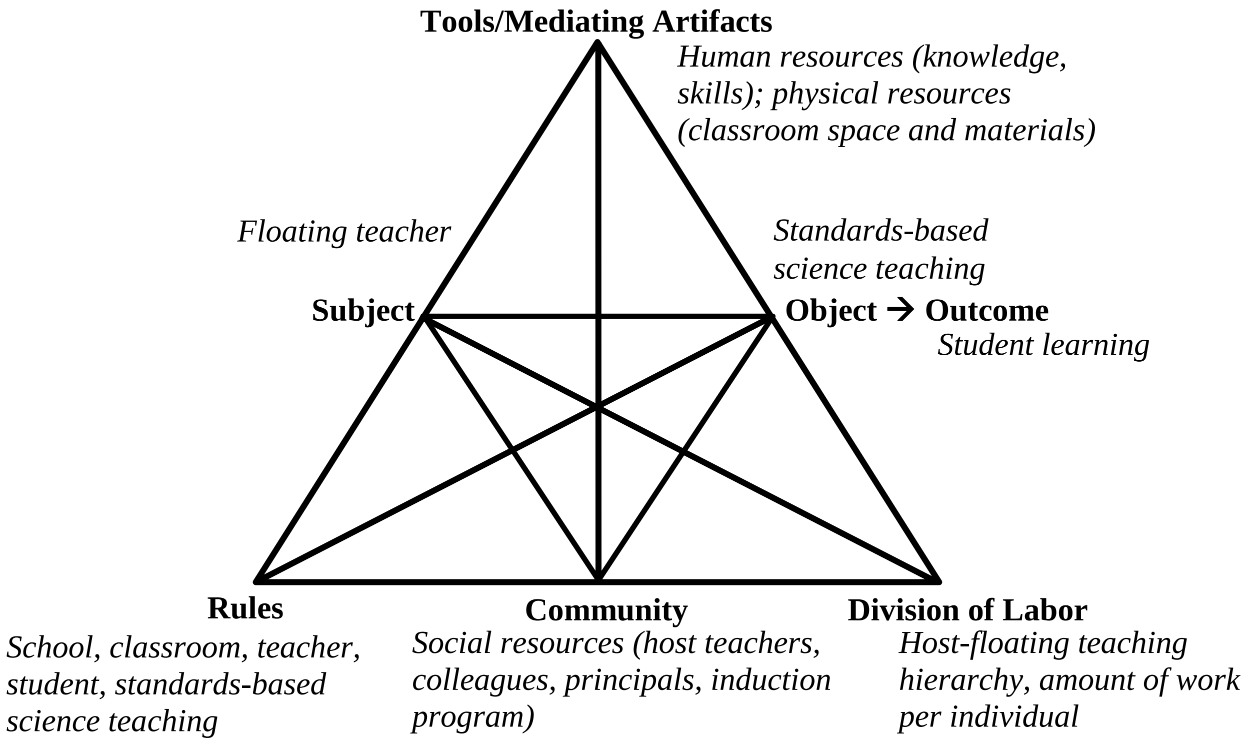

Figure 1. An activity system for floating science teachers

CHAPTER 3

TEACHER LEARNING IN A POLICY ERA: A CROSS-NATIONAL COMPARATIVE STUDY OF BEGINNING SCIENCE TEACHERS' CYCLE OF INSTRUCTION IN SOUTH AFRICA AND THE UNITED STATES[2]

---

[2] Dubois, S.L., Toerien, R., Luft, J.A., & Hewson, P.W. To be submitted to the *Journal of Research in Science Teaching.*

Abstract

Internationally, beginning teachers are in a formative phase of their professional learning trajectory and are informed by global, national, and local pressures. However, little is known about how different levels of policy (macro, meso, micro) influence beginning teachers' actions through an instructional cycle of planning, teaching, and reflection. To increase the knowledge in this area, this study investigates how 12 first, second, and third year chemistry teachers in South Africa and the United States sequence through a cycle of instruction. This is a cross-national and collaborative study, which specifically illuminates the national, regional, and local influences on beginning teachers' instruction. The data included questionnaires, interviews and classroom observations, which were analyzed through policy frameworks and institutional theory. The data analysis revealed how different levels of policy influence teachers differently at different phases in the cycle of instruction, and how there are some differences between first, second, and third year teachers. Finally, this study shows the need for coherence between the levels of policy. It suggests that teacher educators and policy makers must consider how to prepare and support beginning science teachers to achieve these shared global visions in light of rapidly changing policies.

Introduction

International assessments such as the Trends in International Mathematics and Science Study (TIMSS), and the Programme for International Student Assessment (PISA) rank countries according to student performance in mathematics and science. As a result, there is global discussion about students' mathematics and science learning scores. This places increased scrutiny on mathematics and science teachers, and intensifies the focus on the quality of instruction.

In order to support teacher instructional performance, changes in curriculum and policy are underway. For example, in South Africa (SA) post-apartheid, there have been numerous rounds of curriculum revisions from Curriculum 2005 (C2005) which centered on outcomes-based education (OBE) and constructivist teaching to the newest Schooling 2025 which structures pacing guides for when teachers should teach certain topics (Chisholm & Leyendecker, 2008; Hoadley & Jansen, 2009). Similarly, in the United States (US), policy reforms initiating from No Child Left Behind (NCLB) have resulted in standards-based teaching focused on accountability.

Understanding how policy is enacted in the classroom is best determined through studies of beginning teachers who are in a unique phase of their teacher learning and professional career trajectories. Beginning teachers represent the education they have brought forth from their teacher education program. Additionally, this population of teachers provides guidance on the type of professional development that is needed to support the attainment of envisioned policies.

Although similarities in policy and curriculum documents show what policy-makers think should occur for science teaching and learning, little is known about how this influences teachers' day to day instruction. The purpose of this research is to understand how recent trends in globalization in education have shaped the teaching practices and learning experiences of beginning teachers. This study is a comparison of two sites and the cases from SA and the US are intended to develop a rich understanding of science teaching in two places. In order to do this, the guiding questions for this study are: (1) How do first, second, and third year science teachers in SA and the US engage in a cycle of instruction?; and (2) What enables or constrains the actions of a beginning science teacher in a cycle of instruction?

This research of the problem is cross-national and comparative, which is important for three reasons. Education reform at national and local levels is a result of global forces (Tatto, 2006). This results in policy discussions and documents in one country influencing another. These transnational discourses and policies contribute to teachers' knowledge and practice as they articulate what teachers should know and be able to do. Second, comparative education research enhances learning of familiar systems and cultures. Often times, national characteristics remain hidden to members (Blömeke & Paine, 2008). By doing comparative research, implicit understandings of teaching and learning in one's own country can begin to be made explicit (An, Kulm, & Wu, 2004). Finally, cross-national and comparative educational research encourages international dialog and collaboration.

Theoretical Perspective

Institutional Theory

In a teacher education era of policy (Cochran-Smith & Fries, 2005), it is important to understand how policy impacts practice. The transition between policy and practice involves different institutions such as classrooms, schools, or districts. To understand the teaching and learning that occurs within these institutions, this study takes an institutional theory perspective

(Meyer, 1977). In brief, institutional theory considers how local actions are influenced by organizational structures from wider environments.

In taking this perspective, the effects of education are viewed as not fixed and can alter the structure of society. Ultimately, education provides new opportunities for citizens by creating new classes of knowledge that can be incorporated into society (Meyer, 1977). The macro levels tend to contain the micro levels, yet the micro levels can influence the macro levels. Within each level are structures and actions that affect each other. When levels influence each other, change occurs (Wiseman & Baker, 2006).

Institutional theory adopts the idea of a world culture of education, and considers how similar curriculum and educational practices have spread around the world in ways that are detached from local material conditions within nations (Davies & Aurini, 2006). Often, the similarities in curriculum and standards reflect global perceptions of knowledge and practice. Local policies often interact with a legitimate blueprint of curricula and educational practice that create a world culture of education.

More recent approaches to institutional theory (e.g., Wiseman & Baker, 2006) take sociopolitical perspectives into account and consider cross-national variations. This orientation reflects differences rather than isomorphism in knowledge and practice, and potentially understands perspectives that are lost when solely focusing on individuals (Buchman & Parrado, 2006). This approach also assumes that the actual implementation of national policy is not homogenous and is a complex interaction of groups and individuals with various interests (Astiz, 2006; Meyer et al., 1997).

In this study, institutional theory is used to see how macro (national), meso (regional/district), and micro (school/classroom) policy structures influence teachers' knowledge and practice. For example, at the macro level, policy discourse and frameworks for beginning teacher competencies influence curriculum documents and teacher education institutions at the meso level, and ultimately classroom and school policies at the micro level. Within the policies, there are similar discourses stating what it is beginning teachers are expected to know and do.

Review of Relevant Literature

Cycle of Instruction

The cycle of instruction involves phases of planning, teaching, and reflection. Some studies have focused on the entirety of the cycle with beginning teachers (e.g., Forbes, 2004; Zembal-Saul, Blumenfield, & Krajcik, 2000). In these studies, the main challenges existed around the broad area of planning and the institutional factor of time. For planning, teachers had difficulties enacting planned representations of content (Zembal-Saul et al., 2000) and utilizing available curricula resources (Forbes, 2004). As a result, content area colleagues became important social resources for beginning teachers. However, such colleagues were limiting if their instruction was traditional and reinforced standard teaching practices (Feiman-Nemser, 2001; Little, 2003). Additionally, in the cycle, time was a challenge for beginning teachers. They struggled with time to learn content, especially if they taught multiple different courses, and time management for lessons (Forbes, 2004; Loughran, 1994).

Previous research showed that reflection is an important phase to the cycle of instruction. Zembal-Saul et al. (2000) suggested that beginning teachers must have opportunities to reflect on substantive aspects of teaching, and this could be accomplished through guided reflections. Forbes (2004) established a peer mentoring program that allowed beginning teachers to reflect in a supportive environment, and also encouraged them to try more standards-based teaching.

Other studies have examined the individual components of the cycle of instruction with beginning teachers beyond their preparation years. Some of these studies have considered the planning (Williams, Eames, Hume, & Lockley, 2012), curriculum and teaching practices (Powell, 1997; Roehrig, Kruse, & Kern, 2007), implementation of laboratories (Wong, Firestone, Luft, & Weeks, 2013), challenges enacting standards-based instruction (e.g., Bianchini & Cavazos, 2007; Luft et al., 2011; Roehrig & Luft, 2004), examples of beginning teachers' implementing ambitious practices (e.g., McGinnis, Parker, & Graeber, 2004; Windschitl, Thompson, & Braaten, 2011), and beginning teachers' developing knowledge of student learning (Findlay & Bryce, 2012; Lee et al., 2007).

Most of these studies are bound by time and the institution in which the teachers are enacting their instruction. As a result, they offer specific suggestions for those at the school, district or regional level. In addition, there are no studies that examine the process of reflection of teachers over time. These studies would provide information for those who work with beginning teachers.

Policy, Teachers, and Curriculum

Studies on the impact of policy on beginning teachers' learning and development are emerging. While national, state, and local policies are developed differently, they all similarly function to enhance the preparation and instruction of a teacher in order to impact student learning (Johnson, 2013; Shen, Gerard, & Bowyer, 2010). In these studies, there are mixed results showing the impact of certain levels of policy on teachers. Johnson (2013) described micro policies as district and school policies, and macro policies as state and federal policies and indicated that the micro level school and district policies came out as much more prevalent than macro level policies. Additionally, the micro level policies created barriers to overall reform.

Alternatively, Smith and Southerland (2007) used the discourse of national standards, state curriculum, and end of course tests to describe levels of policy. In their study, the state curriculum had the largest impact on the teachers. While both studies revealed different results of policy on teachers, they showed an absence of the national reform policies on the teachers.

Rather than examine all policy levels, some studies have specifically focused on curriculum in light of policy with beginning teachers. Schneider and Krajcik (2002) viewed curriculum as support and argued for educative curriculum materials in order to improve the knowledge of a teacher. Alternatively, Lynch, Pyke, and Jansen (2003) indicated that beginning teachers should learn how to align and adapt curriculum and policy. The participants in the study successfully created teaching units that aligned with the criteria in Project 2061's Curriculum Analysis (American Association for the Advancement of Science [AAAS], 1993) as well as state or national content standards. Schneider and Krajcik (2002) viewed educative curriculum materials as saving beginning teachers time, whereas Lynch et al. (2003) consider the process of adapting curriculum to be an important skill for teachers to learn.

These studies on policy, teachers and curriculum suggest different levels of policy impact teachers differently and that teachers can have positive interactions with curriculum materials that support standards-based instruction. However, policy-makers, and teacher educators must consider the contradictory messages teachers receive from various reform documents and work with teachers to negotiate the tensions and turbulences (Johnson, 2013; Smith & Southerland, 2007). This is important with rapidly changing mandated curriculums.

Cross-National Studies in Science Education

There are some cross-national studies in science education. Aldridge, Fraser, Taylor, and Chen (2000) and Fraser, Aldridge, and Adolphe (2010) studied learning environments in Taiwan and Australia, and Australia and Indonesia, respectively. Other studies have focused on specific topics on concepts in science education cross-nationally (e.g., Leite, Mendoza, & Borsese, 2007; Lindemann-Matthies, Constantinou, Lehnert, Nagel, Raper, & Kadji-Beltran, 2011). These studies showed the influence of national context on the teaching of science.

More recently, Luft, Dubois, Nixon, Campbell, and Bang (in review), examined research on beginning science teachers over 30 years. The studies reviewed came from 12 different countries, and were examined in light of international standards for teachers. Relevant to this study, they found that while there are a significant number of studies that have focused on the professional practice of beginning science teachers, the complexity of factors impacting teacher practice is poorly understood. For instance, collaboration tends to improve instructional practice, but the type and amount of collaboration is not clear.

These studies suggest global policies can be used to understand teaching. They provide a new way to understand national contexts through international comparisons. However, as these comparisons are made, it will be important to consider the reasoning and background for specific contrasts or comparisons.

In Summary

This research addresses three under researched areas with beginning secondary science teachers. First, few studies have examined the full cycle of instruction with beginning science teachers beyond their preparation years. There is little understanding of the substance of the cycle of planning, teaching, and reflection among beginning teachers and how this may change with years of experience. Second, while research on policy and science teachers is emerging, there are certain areas of need. It is still unclear the impact of various policies on beginning teachers, and the affordances and constraints of various policies and policy changes on teacher learning. Finally, this research contributes to the need for more cross-national studies on beginning science teachers. This type of research considers the global and national contexts alongside the local contexts that can influence teachers' instruction.

National Contexts

South Africa

SA is a diverse country with eleven official languages and many cultures. It has a complex education history, with *apartheid* ideology officially infiltrating the country from 1953 through 1994. Under *apartheid*, education was separate and unequal and different departments handled the education for different races. While apartheid legally ended almost twenty years ago, its legacy lives on. Former Model C (i.e., formerly all white) schools are now integrated but still typically have the best facilities, best teachers and best educational opportunities for children.

There are two categories of schooling in SA – independent and public. The vast majority are public schools, which vary greatly according to resources and facilities. To aid national funding initiatives, school rankings are determined on a quintile system from one to five, with quintile one being the least resourced schools (e.g., farm schools), and quintile five being the most resourced schools (e.g., former Model C). Learners in quintile one through three schools do not pay school fees and these schools receive a large subsidy from the government, whereas schools in quintile four and five are fee-paying and receive a much smaller government subsidy.

There are two main routes for teacher certification in SA. A four-year Bachelor of Education (B.Ed) degree or a three to four-year undergraduate degree with a one-year Post Graduate Certificate in Education (PGCE). Many current teachers with more than 12 years of experience were trained at teachers' colleges and not at universities. These colleges were closed in the early 2000s to enhance the quality of teacher training in SA. Since then, teacher education is the responsibility of the tertiary education institutions which certify a total of 7,000 teachers each year (DHET, 2011). However, SA needs about 15,000 new teachers each year, so the teacher quality problem, in addition to that of attrition, is also one of teacher shortage.

For science content, Natural sciences is compulsory from grades four through nine and consists of four knowledge areas, namely matter and material, energy and change, life and living, and earth and beyond. This provides the basis for the Further Education and Training band for grades 10-12. At grade 10 level, students choose any combination of the following subjects to study for three consecutive years: Physical Sciences, Life Sciences, or Geography. Chemistry and Physics are offered as Physical Sciences.

The content for each subject is specified by the national curriculum statement. Over the past 10 years teachers have been guided by three different curricula. For Physical Sciences, *A Résumé of Instructional Programmes in Public Schools, Report 550* (NATED 550) was in place until 2005 when a staggered implementation of the National Curriculum Statement (C2005) began. A revised version of C2005 was implemented in 2006 in Grade 10. Most recently, in 2012, teachers started teaching according to the Curriculum Assessment Policy Statement (CAPS). Although the science content remained similar through all the policy statements, the philosophical underpinnings varied greatly.

United States

The US is a diverse nation with no official language. The US has a complex education history, with the end of segregated schooling for black and whites beginning with the *Brown vs. Board of Education* decision in 1954. However, the effects of separate schooling are still visible today, with many disparities and inequalities in school quality and infrastructure.

There are two broad categories of school types in the US: public and private and there is much variation within these categories. For instance, public schools include traditional, charter, magnet, and alternative schools. Private schools include independent and parochial schools. Regardless of school type, schools are also classified as urban, suburban or rural and are ranked by socioeconomic status (SES), which is an indicator of poverty in the US. Schools are ranked as high, medium, or low SES based on the number of students who receive free or reduced lunch (FRL) from the school.

In the US, there are many different paths and ways to earning initial teaching certification. The two broad areas are traditional and alternative routes, but there is much variation within these. The most common traditional routes are acquiring a teaching certificate through a four-year Bachelor of Education (B.Ed.) program or a five-year combined B.Ed and Masters of Arts in Teaching (MAT) program. Alternative programs can vary from virtually no teacher preparation and emergency certification, to two year MAT programs following a B.S. degree in a subject area. Online teaching degrees are also increasing in the US with approximately 6,000 degrees granted in 2011. Attrition rates for beginning math and science teachers are around 50%.

In the US, each state has its' own scope, sequence, curriculum standards, and assessments for the science disciplines. However, in general, students take Earth Science in sixth grade, Life Science in seventh grade, and Physical Science in eighth grade. Biology, Chemistry, Environmental Science, Physical Science, and Physics are high school science courses. The courses vary for the different academic trajectories of the students. The National Science Education Standards were published in 1996, and have influenced most state curricula. The Next

Generation Science Standards (NGSS) (Achieve, 2013) has been recently released and may or may not influence science curriculum.

SA and the US

Cross-nationally, SA and the US have unique educational structures, but there are some similarities. Both countries have similar historical backgrounds, deeply rooted in oppression and segregation. Both countries also have decentralized governments, with various levels of control and policies. As a result of a decentralized system, SA and US teachers and learners have experienced numerous rounds of policy reforms and curriculum revisions.

Additionally, there are similar competencies for beginning teachers in SA and the US. In SA, *The Minimum Requirements for Teacher Education Qualifications* (Republic of South Africa Department of Higher Education and Training [DHET], 2011) lists eleven basic competencies for beginning teachers. In the US, *InTASC Model Core Teaching Standards: A Resource for State Dialog* (Council of Chief State School Officers [CCSSO], 2011) states ten standards for beginning teachers. The analysis of these documents revealed three broad categories important to a cycle of science instruction: Planning and designing instruction, teaching and applying content, and reflection and professional learning.

Research Methods

Design Overview

In order to better understand the science instruction of beginning science teachers cross-nationally, this is a qualitative study of 12 beginning chemistry teachers in SA and the US. A qualitative study is ideal for this emerging, but unexplored area (Bogdan & Biklen, 2007). The study was designed around the cycle of instruction which includes planning, teaching, and reflection as described in Zembal-Saul et al. (2000). The design, data collection and data analysis were collaborative between a team of researchers in SA and a team of researchers in the US.

There were five phases to the overall design of this cross-national study. The first phase occurred from August through December of 2012. During this time, weekly Skype meetings were held in which researchers in both countries designed the interview protocols, discussed national education structures, and determined how to recruit participants. Phase two was in January 2013 when SA researchers visited the US to discuss data collection, experience the education system and culture, and attend a national science education conference.

The third phase was from February 2013 through May 2013. In this phase, researchers in both countries collected data on participants in their respective countries. Phase four was in June 2013 when researchers from the US went to SA to visit a variety of schools and observe some of the participants' classrooms. In addition, all researchers attended a SA research school, where the doctoral students shared their cross-national research ideas.

The fifth phase involved the data coding and analysis. Transcription and discussion of data occurred from July 2013 to October 2013. The qualitative coding of interview and observation data occurred in November through December 2013. This coding was done entirely collaboratively between one SA and one US researcher.

This paper is the written product of a collaborative and team research project that was implemented in two countries. It is by no means the end of the project, which has fostered and strengthened research relations and dialog between the researchers in the two nations.

Participants

There are six participants from each country – two first-year, two second-year, and two third-year teachers. The participants were selected because they were beginning chemistry teachers in the countries of interest, and they agreed to participate in the study. In SA, participants came from the Gauteng and Western Cape provinces and in the US, participants came from three districts in the Southeast. Table 1 shows the demographics for the SA participants and Table 2 shows the demographics for the US participants. All participants are referred to by pseudonyms.

There are some areas between SA and the US that need to be discussed as the school categories between the two countries are different. All of the SA teachers taught at public and former Model C schools. These schools rank in quintiles four and five, which are equivalent to the comparison schools in the US. Quintile one and two schools were not accessible to SA researchers. In the US, all of the participants taught in public schools. One of the schools was a magnet school, where students entered the school based on a lottery system, and one was an alternative school where students attended if they had been removed from a traditional school. Although the US participants were in a range of SES schools, in the SA quintile system, these would all be ranked as four or five.

Table 1

Demographics of South African Participants

Pseudonym	Year	Degree	Subjects Taught	School Type	School Quintile
Daniel	1	B.Sc., PGCE	Math, Physical Science	Former Model C	5
Lerato	1	B.Ed.	Math, Physical Science	Former Model C	5
Brenda	2	B.Sc., PGCE	Math, Physical Science	Former Model C	5
Albert	2	B.Sc., PGCE	Natural Science, Physical Science	Former Model C	5
Richard	3	B.Sc., PGCE	Natural Science, Physical Science	Former Model C	5
Nandi	3	B.Sc., PGCE	Math, Physical Science	Former Model C	4

Table 2

Demographics of United States Participants

Pseudonym	Year	Degree	Subjects Taught	School Type	School SES
Aaron	1	B.S., MAT	Biology, Chemistry	Traditional	High
Addie	1	M.S., MAT	Chemistry	Traditional	Medium
Aubrey	2	M.S., MAT	Chemistry	Magnet	High
Marisa	2	B.S. Biology	Online Biology & Chemistry, Chemistry	Alternative	Low
Heidi	3	B.S. Biology	Chemistry, Astronomy	Traditional	Low
Madison	3	M.S., MAT	Chemistry, Physics	Traditional	High

Data Collection

Prior, during, and after data collection researchers established and developed rapport with participants following guidelines suggested in Seidman (2006). The rapport was controlled, which meant the researcher-participant relationship was guided by respect and interest, and had a purpose of moving forward with understanding the participants' experiences in the midst of the research. The researchers were non-judgmental in the data collection process and established a familial yet formal relationship with the participants through respectful emails, conversations and interactions. In some instances, the researchers knew the participants from the university teacher education programs. In these cases, researchers were careful not to establish a "We relationship" (Seidman, 2006, p. 96) and stay true to the participants words and experiences.

There were five data sources in this study. One source of data was an online questionnaire that obtained information about the participant's backgrounds and educational experiences. This document was collaboratively developed among the SA and US researchers to collect demographic data useful to the project. Example questions from this document included: Briefly describe your methods, pedagogy, and content courses; and briefly describe your classroom and physical resources available to teach science. Participants completed this prior to the collection of the next data source.

The second data source was a pre-observation interview that occurred prior to the classroom observations. The purpose of this interview was to learn about the teachers' planning process. Questions in this interview consisted of: Can you tell me about your planning to teach? Where do you typically obtain lessons or ideas for lessons? Is collaboration important in your department/school? How do you decide what to teach or what not to teach? This interview was also co-constructed by the research team.

A third source of data was a three-consecutive day teaching observation that occurred around a single chemistry topic. During an observation, the classroom instruction of a teacher was documented using the Collaborative for Excellence in Teacher Preparation core evaluation classroom observation protocol (CETP-COP), which was piloted and refined by Lawrenz, Huffman, Appeldoorn, and Sun (2002). This classroom coding process documents type of classroom activity, student attention to lesson, cognitive load of the lesson, and classroom organization at five-minute intervals (see Luft, 2009; Luft et al., 2011 for a description of use).

A fourth data source was collected during the observations, and consisted of field notes. Field notes were taken during an observation and reviewed after the observation and followed guidelines from Bogdan and Biklen (2007). The notes were descriptive of student actions, teacher actions, classroom environment, and classroom resources.

Lastly, a post-observation interview gathered information about reflections on the lessons and how the teachers have learned over the year(s). This interview was also collaboratively developed and consisted of questions such as: Did they lessons go as expected? If you teach this lesson again, what would you do differently? How have you learned over the year(s) as a science teacher? Like the other interview, the protocol provided by Seidman (2006) was followed by the researchers. This allowed for exploration following a participant's answer. The questionnaire and interview guides are included in the appendices.

Prior to the collection of data, researchers practiced the data collection process in order to ensure consistency in terms of the data collected among researchers. To ensure the validity and reliability of the findings, multiple methods were used by multiple researchers to collect multiple sources of data. This contributes to methods, data, and investigator triangulation. In addition, the variation in sites and participants further enhanced the validity of the findings (Merriam, 2009).

Data Analysis

The data analysis began by examining the SA and US policy documents for the basic competencies and standards for beginning teachers. From this analysis, the areas of planning and designing instruction, teaching and applying content, and reflection and professional learning were the primary areas of interest in this study and guided the analysis of the data. Coding and data analysis was completed collaboratively by one SA and one US researcher and followed guidelines in Miles, Huberman and Saldaña (2014) and Saldaña (2013). All data were uploaded into NVivo software for coding and data management.

Coding involved a two-level scheme, and was partway between *a priori* and inductive approaches (Miles, Huberman & Saldaña, 2014). First, a general accounting scheme was created that pointed to the general domains in which codes could be created. This accounting scheme resulted in folders in NVivo that included: content, culture, planning, instruction, reflection, students, support, teacher knowledge, and teacher values. Within each of these domains, codes were developed inductively and these were the second level of the coding scheme.

The coding process followed the first and second cycle coding descriptions provided in Saldaña (2013). This emphasized the cyclical rather than linear nature of qualitative analytic processes. In the first cycle of coding, initial coding was done line-by-line for data from six participants, three from each country. This initial coding used both *in vivo* codes capturing the participant's true words and researcher codes that described the essence of what the participant was saying.

In the second cycle of coding, both researchers looked closely at the initial list of *in vivo* and researcher codes created during the initial coding process. Codes were consolidated and re-worded to capture broader descriptions of participants' experiences. During the second cycle of coding, both researchers deeply examined the codes to create categories that represented the significant portions of the data within each main folder. In doing this, some of the main folders changed. For instance, from the reflection folder, teacher learning came out as a large enough code to be its' own category. Therefore, teacher learning was created as a separate folder. Additionally, the category of teacher values was examined and found to contain more of teacher views than values and so this category was re-named.

After a new list of codes and categories was established, researchers created a code book (See Appendix) listing definitions of the codes (Miles, Huberman & Saldaña, 2014). Researchers than went back and re-coded the first six participants with the new coding structure. The remaining six participants were coded and cross-checked by both researchers. If there was disagreement on the code, discussion would occur until consensus was reached.

Validity and reliability during the data analysis stage followed guidelines in Merriam (2009). Specifically, multiple researchers coded the multiple sources and methods of data contributing to triangulation. Additional validity strategies included discrepant case analysis and peer review. In the discrepant case analysis, researchers purposefully looked for data that disconfirmed the overall emerging findings. With the peer review, researchers continuously sought feedback and advice from peers throughout the coding and analysis process.

Findings

The findings are presented overall for each of the phases in the cycle of instruction for both countries. Following the overall presentation of findings, two discrepant cases are presented that highlight some disconfirming data.

Planning Phase

Two areas emerged from the coding around planning, with the first area focused on the planning format. In SA, the beginning teachers planned individually. Sometimes, they would share ideas with colleagues, but there was no scheduled meeting time to plan together. As Albert indicated, “a lot of it is just based on my own knowledge and what I know about how a section should go, and what direction it should flow in” (Pre-Interview, March 11, 2013).

In the US, the beginning teachers planned collaboratively. School policies required teachers who taught the same discipline to meet one or two times per week for common planning. However, within this policy, there was much variation and teacher autonomy. While schools wanted their teachers to be teaching the same ways, many US teachers explained they would modify the materials for their specific classes of learners. For many teachers, autonomy is a good thing. As Aubrey stated,

> Ah yes, collaboration. It is a big thing in our school… the other chemistry teacher and I, we give the same tests and the same days… And this is the way that we collaborate. We go at the same topic and the same pace and cover the same topics. We expect the students to know the same things, but how we will present the lessons, it is up to us…. If we like

> each other's … we always share... How people collaborate here, kind of do the same but the way they feel like doing it. I don't know if I would be able to teach if I was forced to do something like other people do. (Pre-Interview, February 28, 2013).

This collaborative structure for planning included resources, such as emailing colleagues all lesson materials, or putting packets together as a group. The influence of social resources in the form of colleagues is prevailing for the US teachers. As Addie stated, "I've got a drive of all their resources. And we co-plan so I have a lot from the chemistry teachers here" (Pre-Interview, February 19, 2013).

The second area focused on the consideration of the teachers while planning. For the SA teachers, the most common consideration when planning was the mandated curriculum. This included the curriculum document, CAPS, and the teaching schedule that was distributed by district. For the second and third year SA teachers, there was also the consideration of changing curriculum. As Richard commented, "With the new CAPS, I try to just adjust it slightly" (Pre-Interview, March 12, 2013). The SA teachers who experienced the rapidly changing curriculum made frequent instructional modifications to their lessons. In addition to the curriculum, SA teachers also considered and relied on content resources such as the textbook.

Similar to SA, in the US, the most common consideration when planning was the mandated curriculum. As Aaron remarked, "That's where we always start at is the standards and sort of move backwards from there. Make sure you're covering the standards" (Pre-Interview, February 28, 2013). Second to the curriculum, US teachers also considered variations in student ability and diversity when planning.

Teaching Phase

At first examination, the teaching phase in the schools in SA and the US appeared similar. There was an emphasis on providing information to students through lecture, discussions, and worksheets. This instructional format emphasized students receiving information, memorizing facts, and learning how to work problems. Class organization was frequently whole group and individual. The teachers in both countries commonly managed the classroom space by walking around and monitoring student progress. The content itself was most often represented in a factual way, with the prevailing code as defining science words.

Closer examination revealed different orientations towards teaching the content. In SA, topics observed were balancing equations and chemical bonding. With these topics, in addition to defining science words, the SA teachers often explained the content by using examples. For instance, Daniel's instruction was often infused with examples. During the third observation he explained how to balance equations using the following examples: 1. $N_2 + H_2 \rightarrow NH_3$; 2. $Na + HNO_3 \rightarrow NaNO_3 + H_2$; and 3. $Al + O_2 \rightarrow Al_2O_3$. Additional examples were provided for learners to try on their own: 4. $Ca + O_2 \rightarrow CaO$; 5. $K + Cl_2 \rightarrow KCl$; and 6. $Mg + N_2 \rightarrow Mg_3N_2$ (Field notes, Observation 3, April 25, 2013). Secondly, no actual laboratories were observed during observations of teachers' instruction because laboratory practicals are specified separately in the curriculum documents, and therefore are not integrated into instruction in SA.

In the US, topics observed were acids and bases, chemical reactions, and solutions. With these topics, US teachers commonly organized students in small groups. In doing so, US teachers encouraged student participation by asking questions to specific groups or individuals. For example, in Heidi's class, she called on groups to answer how to determine the limiting reactant (Field notes, Observation 3, February 8, 2013). Sometimes, teachers organized students into groups to do a laboratory exercise. Although laboratories were not common, the US teachers often contemplated how to incorporate laboratories into instruction.

One difference between the SA and the US teachers pertained to the laboratory instruction. Viewed as an important part of science, it is national policy in SA to have laboratory practicals and the laboratory practical work is specified separately from the content in the policy document. The SA teachers are expected to do three to four formal laboratory practicals per year, and the compulsory formal practicals are documented in the mandated curriculum. In the US, the expectation is that teachers will integrate laboratories as part of their topic curriculum, and the laboratories will conceptually relate to the content instruction.

Reflection Phase

On planning. In the reflection phase of the cycle, the beginning teachers in SA and the US reflected on their planning and teaching. In SA, there was considerable reflection on planning. The SA teachers frequently reflected on the time it took to plan, especially when teaching multiple subjects or subjects for the first time. Brenda reflected on the time it took to plan over her two years of teaching. She mentioned, "I planned more last year...because last year I had one less class so I had one more free period, so I could plan the lessons and the structure a bit more than this year. This year I get one free a day, if I am lucky... so find time to plan, that is the issue. The time" (Post-Interview, May 9, 2013).

Among the US teachers, there were few instances of reflection on planning. When this reflection did occur, it was in reference to finding time to plan for multiple science disciplines. For example, Madison, a third-year chemistry teacher was teaching physics for the first time. This impacted where she allocated her planning time. She remarked, "But since I did all that work upfront … with the inquiry experiences I developed [for my chemistry class], I haven't changed much. My original plan was to work on [my chemistry lessons] a lot this year, but now I'm teaching physics so I'm working on that a lot instead" (Pre-Interview, March 12, 2013). She goes on to mention that it took her more than three times as long to plan for physics as it did for chemistry.

A main difference in the reflection on planning was that the SA teachers were impacted by the multiple rounds of curriculum revisions. In some instances, the mandated curriculum revisions were positively impacting beginning teachers' instruction, while in other instances there was a negative impact on instruction. For example, the constant changes in curriculum resulted in teachers continuously revising their lessons and reflecting upon the presented content. As Richard commented, "we have a new syllabus this year so it makes it easy to say I am going to prepare better because I am redoing most of what I have done before" (Post-Interview, April 14, 2013). This prevented him from using the same material from year to year. For Albert, the change in curriculum caused him to critically consider the content. He stated, "This specific section that we've looked at, the bonding bit is quite important, about the electrons and what is happening to the electrons. The shapes, it's limited in terms of the big picture" (Post-Interview, March 14, 2013).

On science teaching. In terms of reflection on science teaching, there were similarities and differences with the SA and US teachers. In both groups, teachers contemplated the learning of their students, with this type of reflection increasing with years of teaching experience. Additionally, the SA and US teachers frequently reflected on their use of general instructional strategies. For example, they considered how they could include more visuals, change the introduction of the lesson, spend more time making a worksheet, or decide what student work to collect for a grade.

A main difference in the reflection on teaching was that the US teachers also commonly reflected on science specific instructional strategies. In particular, they desired to do more laboratories in future lessons. The US teachers often contemplated using different instructional approaches. Addie, for example, commented:

> One thing I would love to do … is some type of lab or activities for them to do. To actually work with solutions and look at the properties. Like they could look at a saturated solution, look at something that's not soluble... It's just really hard to fit in … with 50 minute lab times. It's hard to kind of fit those in and pick and choose what to do labs with … (Post-Interview, February 13, 2013).

Discrepant Cases

In order to add validity to the findings, two example cases are presented that demonstrate components of standards-based teaching with a beginning teacher from SA and the US.

Albert

Albert is a second-year SA teacher who has a B.Sc. in astrophysics and a PGCE. His initial career plan was to conduct research in astrophysics, but he decided instead that he wanted to become a teacher and took a teaching bursary which helped him pay for his studies. He comes from a family of educators and was always interested in education. During high school, he started teaching extra lessons to his friends and during his time at the university, he provided tutoring to first-year students (Pre-interview, March 11, 2013). His current school provided him with a learnership opportunity and financial support to teach one Physical Science class per day while completing his PGCE. The school is well-resourced, supports teachers, and has been using the learnership model for 10 years. He has Natural Science classes of grades 8 and 9, and Physical Science classes of grades 10, 11, and 12.

For planning, Albert created most of his own lessons. Although not required, he shared these lessons with his colleagues through a shared drive folder on the internet. When planning, he critically examined the curriculum changes in SA. He commented, “basically an entire syllabus had come and gone between when I matriculated and when I started teaching, which is quite remarkable” (Pre-Interview, March 11, 2013). The curriculum changes forced him to be critical of the content in the curriculum, which helped him craft his instruction.

Albert’s instruction was student-centered. For instance, on the first day of observations of his grade 11 class, he was reviewing material that he covered in grade 10. He asked a few questions of his students about the topic chemical bonding which allowed him to assess what the students learned previously. This knowledge was used to guide the following lesson, which had students build molecules and represent them through Lewis diagrams.

Throughout all of the lessons, Albert focused on interacting with students and providing the best instructional representation possible. This format was evident when he was teaching about Lewis diagrams. His lesson began with a series of question about the number of electrons around carbon. It continued with the questions: “How many electrons does oxygen contribute?” He then used the learner’s answers to guide his next question, either to the same learner or to a new learner (Field notes, Observation 2, March 12, 2013). In the final lesson, Albert incorporated an informal laboratory practical that included a demonstration and a simulation where students were able to move electrons and see the changing molecular shapes.

In his reflection of the lesson, Albert certainly emphasized the changes in the national curriculum and how this impacted his plan to teach the content. In doing so, he was critical of the content that he taught. His reflection, which focused on the content, revealed his thoughts on the lack of inclusion of molecular shapes in the new curriculum. This is indicated in his statement:

> The only thing that I've found quite interesting in this bit was when comparing and looking at the curriculum statements carefully and scrutinizing them, is that they've mentioned these five ideal geometries for electron structure, but they don't refer to them as electron structure, they only leave them as five ideal geometries, and they say you've got a central atom, and you've got only terminal atoms, no lone pairs on your central atom, and it says nothing about the shape of, and then they end it at that… Nowhere did they actually talk about a bent molecule, or a trigonal pyramidal molecule, and those are quite big ones, which I did teach, last year. (Post-Interview, March 14, 2013).

For student learning, he reflected on the close relationship between assessment and learning. He mentioned, "from the informal assessment in class of just selecting individual students to give answers, it definitely seems like they are, you know, getting it. Especially when it comes to the revision of how many valence electrons" (Post-Interview, March 14, 2013). He based his instructional decisions and sequence on the knowledge of his students.

Aubrey

Aubrey was a second-year US teacher. She taught all chemistry courses at a math and science charter school, where students were accepted to the school based on a lottery system. As a child, she often experienced science through gardening and observing her parents repair materials that were broken. This inspired her to pursue an M.S. in agriculture and engineering before her MAT. She was certified to teach chemistry and physics, but she has only taught chemistry. She also received additional funding to order science materials for her classes because of a special scholarship she received for her teacher education. Her colleagues and school environment were supportive of her science teaching.

In terms of planning, there was a push for collaboration at Aubrey's school, but there was still teacher autonomy. Teachers shared lesson plans, materials, and assessments, but no one forced the teachers to use the plans as they were. The teachers could modify or create their own lessons as long as they covered the content in the curriculum. Aubrey often shared ideas and lessons with the other chemistry teacher. She also frequently looked in chemistry education journals for lesson ideas. When she thought about planning, she stated "I think about the specific concept and how I understand it and what I need to do in order to help students understand it" (Pre-Interview, February 28, 2013). Her focus shifted from herself to her students.

For her teaching, Aubrey created an environment that allowed students to confront their ideas. She engaged her students in an inquiry lab on the different properties of acids and bases. In the first day of observations, students went around to six different laboratory stations making observations of what they saw with different chemicals and their properties. In the second day, Aubrey engaged the students in a discussion where they talked through the students' observations from the laboratory. Aubrey made sure all the students were participating in the discussion. Furthermore, the lesson was guided by comments of the students. This type of sequence was evident by questions she asked to guide the discussion. For example, she asked, "How did you know there was a reaction? Did the reactions occur right away? Why did the reaction happen?" (Field notes, Observation 2, March 15, 2013).

In her reflection of the lessons, Aubrey focused on some general instructional strategies that she could do differently, such as how to structure the post-lab questions to be more analytical. However, she also critically reflected on content and student learning. She considered what her students knew from the lesson, what they struggled with, and where she should focus her attention on the next lesson. This level of reflection is evident in her statement:

> OK. For now, they understand that there is a difference between the two categories of solutions that we are testing and we are trying to separate them. What is not clear for them yet is that some of the differences of how fast some of the solutions reacted probably is based on concentration first and then the fact that some of the acids are weak, some of them are strong. Also the electroconductivity, they were able to determine that not all of them conducted not exactly in the same way but still they don't realize what is the reason for that difference. This is where they will struggle and this is what we need to focus on in the next classes. (Post-Interview, March 15, 2013).

Discussion

The first question in this study asked how first, second, and third year science teachers in SA and the US engaged in a cycle of instruction (planning, teaching, and reflection). There were some similarities and differences overall between the teachers in the countries. Institutional theory offers insights into these changes, and illuminates the role of micro, meso, and macro policies within this cycle.

In terms of planning, there were differences between the SA and US teachers, but not between first, second and third year chemistry teachers. One significant difference was in the approach towards planning. In SA, planning was primarily an individual process with no required meeting time to plan with colleagues. This individual planning process resulted in support from content resources, such as the textbook, which encouraged consideration of content ideas. In the US, chemistry teachers were required to plan with colleagues in their department, but there was still a degree of teacher autonomy within this planning. This collective planning opportunity resulted in collegial support and a focus on instructional strategies to teach the content. As a group, teachers discussed the topic of instruction and shared instructional approaches to support student learning.

In both countries, the beginning teachers who taught multiple courses or new courses experienced tensions with time to spend planning for instruction. With one course, a beginning teacher could focus on the curriculum. Multiple courses, however, required the careful parsing of one's allocated planning time.

Micro policies at the school level were often responsible for collaborative or individual planning, and the different courses beginning teachers were assigned to teach. These policies, which were established formally or informally, provided specific times for teachers to meet and established the working culture. By planning collectively, colleagues may encourage one another to critically examine their instructional strategies to teach the content or they may continue to enact the instruction that is the norm at the school (Feiman-Nemser, 2001; Little, 2003). By planning individually, teachers may become more familiar with the content to be taught and think critically about the content.

In this study, both collaboration and individual planning resulted in more attention towards the content. These two positions illustrate a potential relationship of micro and meso policies. It was the micro policy among the SA and US teachers that facilitated the connection to the meso policy (content instruction), in different ways. In SA, the teachers learned the content. In the US, the teachers focused on instructional strategies to teach the content. In order to better support content instruction, a more structured approach towards planning for beginning teachers may be appropriate. More structure would support the enactment of the content in the midst of different micro policies.

For the teaching component of the cycle of instruction, there were few differences between the SA and US teachers. The beginning teachers in both countries focused on the mandated curricular content. This guided the science content that was represented during their instruction. One significant difference between SA and US teachers was the teaching portion of the cycle that included laboratory instruction. For the teachers in SA, laboratory practicals are an important component in the science curriculum. However, these are separate from the content in the curriculum, and are enacted in classroom time designated only for laboratories. In the US, laboratories are a national expectation for science teaching. As a result, teachers try to incorporate laboratories into their instruction to teach or reinforce scientific concepts.

Among the first, second, and third year teachers, only in SA were there differences in the teaching portion of the cycle of instruction. In particular, the rapidly changing mandated curriculum influenced the instruction of the second and third year teachers who had experienced rounds of revisions. As a result, second and third year teachers critically examined the content in the newly mandated curriculum and revised their lessons accordingly.

Meso policies at the state or provincial level are often responsible for the inclusion of content in the curricular materials. For beginning teachers, the mandated curriculum and curricular materials are clearly an important influence on their instruction. Previous researchers suggested that curricular materials should be educative (Schneider & Krajcik, 2002). For the teachers in this study, educative materials would have supported their instruction, but they would not have been sufficient. For long-term and sustainable approaches, the combination of educative curriculum materials and equipping teachers with the knowledge and skills to align and adapt curricular materials (Lynch et al., 2003) is more sustainable and ensures continued sound science instruction.

In this study, for different reasons, laboratories did not occur often in the instruction of the beginning science teachers. This may be attributed to a weak connection between macro, meso, and micro policies. In SA, there is macro policy pertaining to the structure of laboratories, but teachers decide how to implement the laboratories. In the US, however, laboratory instruction is often at the discretion of the beginning teacher but can be influenced by school or district programs (Wong et al., 2013). For both the SA and US teachers, laboratory instruction is largely influenced by meso policies. In order to support laboratory instruction among beginning teachers, meso policies must be developed that clearly connect to both macro and micro policies. For instance, induction programs specific to science should be mandated at the meso level and enacted at the micro level, but required at the macro level. This structure ensures that science is taught in an appropriate way.

While the reflection component of the cycle of instruction was similar between the SA and US teachers, there were differences between first, second, and third year teachers. Specifically, there was increased reflection on student learning with years of experience in both countries. However, this reflection did not attend to the content that was being taught. That is, the beginning teachers reflected on the instructional strategies, differentiation, and the organization of the classroom, and not the adequacy of the content. This is not surprising, as several studies noted this shift (e.g., Findlay & Bryce, 2012; Lee et al., 2007).

Macro policies at the national level include reflection as an important competency for beginning teachers (Luft et al., in review). However, after a teacher completes his or her teacher education program, reflection is not a formal component and is often conducted informally on a personal basis. This research notes this void, and suggests that guided reflection should be included in support programs provided to beginning teachers. Guided reflection, as discussed by

Zembal-Saul et al. (2000), could help beginning teachers reflect on both science content and student learning.

In this study, the reflection component of the cycle indicated weak connections between macro, meso, and micro policies. The macro policies of beginning teacher competencies in both countries articulated that teachers engage in reflection of their teaching. However, the teachers in this study reflected on the students, but not the science content. A meso policy for a structured and guided approach to reflection beyond teacher certification and into the first years of teaching will support macro policies, and provide clear guidance at the micro level. Such a policy change would ensure the alignment of the policies and an ongoing emphasis on the reflection of student learning and content instruction.

In summary, this study highlights the influence of different levels of policy on the three phases of the instructional cycle for beginning science teachers. The influence of the various levels of policy were, overall, consistent whether the teachers were in their first, second, or third year of teaching. For planning, micro policies prevailed and facilitated connection to meso policies. For teaching, meso policies were the most influential, yet there was an absence of curricular materials to teach science in standards based ways. For reflection, macro policies supported the reflection construct, but there was an absence of meso and micro policies that formally facilitated the enactment of reflection on content learning. Within each component of the cycle, structured approaches may alleviate some of the disconnections among the levels of policy.

The second research question of this study sought to understand the enabling and constraining factors that influenced the actions of a teacher in a cycle of instruction. The results of the analyzed data indicated different types of enabling or constraining factors. Specifically, it seems that the type of instruction a beginning teacher enacts is a result of a combination of institutional and personal factors.

Institutional factors in the form of time and the mandated curriculum enabled or constrained the quality of the beginning teachers' science instruction. Time is often recognized as a challenging factor for beginning teachers (Forbes, 2004; Loughran, 1994). Teachers in both countries were often limited with time to plan for multiple classes or to teach science in standards-based ways.

The curriculum was also an enabling and constraining factor. The SA and US teachers often referred to the national, regional, or local curriculum in terms of the content to be learned by the students. As noted previously, the changing curriculum in SA caused the teachers to constantly change their lessons from year to year and remain continuously critical of the content.

Institutional theory considers structural factors that can shape teachers' actions. The institutional factors in this study are a result of micro and meso policies. Micro policies at the school have a direct impact on how teachers allocate their planning time, and the duration of instructional periods. As explained before, the meso policy of the curriculum directly influenced teachers' science instruction.

The second type of enabling or constraining factors in this study were personal factors. Examining the discrepant cases of Albert and Aubrey, it is clear personal factors in the form of content knowledge and knowledge of students helped them to teach the content in standards-based ways. They were knowledgeable and critical of the chemistry content, and focused on student learning. This knowledge and experience may have assisted their creation or modification of lesson materials in order to align with standards-based instruction.

Institutional theory largely accounts for the structures acting outside of an individual. However, the “sub-micro” factors within an individual clearly existed simultaneously with external micro, meso, and macro policies. The findings from this study support that teacher content knowledge and knowledge of students, sub-micro factors, can act in accordance with macro policies for science teaching.

The institutional and personal enabling and constraining factors show the importance of coherence between levels of policy. With coherence, there is an added benefit to the policies. Without such coherence, the benefits at one level may be eliminated by the constraints existing at another level.

Summary and Implications

This study adds to the literature on beginning teachers by focusing on the various levels of policy that influence teacher learning and development. It is a study that can shed light on some factors that influence teachers globally, nationally, or locally.

This research agrees with Johnson (2013) in that micro polices are largely influential in the cycle of instruction, particularly in the planning phase. It also agrees with Smith and Southerland (2007) that meso policies in the form of the curriculum are largely influential, particularly in the teaching phase of the cycle. It adds that macro policies have potential for being the prevailing influence on beginning teachers’ reflection. It appears that no single level (micro, meso, or macro) is more influential than another as they all interact and inform the instruction of a beginning teacher.

From this cross-national study, there are implications for teacher educators and policy makers. First, curricular materials are clearly important to beginning teachers; teachers must think critically about the content they are expected to teach, substantially reflect on content, and consider student learning of the content. It also means that teachers must be equipped with the knowledge and skills to revise their instruction – within the midst of changing policies. While teacher educators work with teachers, policy makers need to collaborate closely with teachers and teacher educators as they consider policy changes. Without this collaboration, teachers and teacher educators will be scrambling to meet the stated standards.

Second, initial certification teachers need to learn how to modify their instruction in light of student knowledge, and this needs to be supported through the first years of teaching. To accomplish this, teacher educators need to provide ample learning experiences with students during initial certification and they need to ensure that new teachers know their content. Policy makers need to provide ample funding or guidelines to ensure that the opportunities to learn about students and the content are continued in a teacher's first years of teaching. Even though national policies support an understanding of students and content knowledge, there are limited provisions to guide this ongoing development.

Finally, teacher educators and policy makers must strengthen the communication and coherence between the levels of policy that influence the instruction of science teachers. Teacher educators have a fundamental responsibility to talk to policy makers and educational leaders. They must advocate for their teachers. Policy makers have a fundamental responsibility to talk to teachers and teacher educators, and to look beyond their own political interest. Policy decisions need to be informed by the experiences of teachers and teacher educators, as well as research in the field, but guided by the global need for students to participate fully in our scientifically oriented world.

Acknowledgements

The authors of this study would like to recognize the following research assistants and faculty who helped with various parts of this study: Annemarie Hattingh, Melissa Jurkiewicz, Elizabeth Mavhunga, and Ryan Nixon. This study was made possible in part by the National Science Foundation grant 0918697 and the Sasol Inzalo Foundation. The findings, conclusions, and opinions herein represent the views of the authors and do not necessarily represent the view of personnel affiliated with the National Science Foundation or the Sasol Inzalo Foundation.

References

Achieve (2013). The next generation of science standards. Washington, DC: Achieve.

Aldridge, J.M., Fraser, B.J., Taylor, P.C., & Chen, C. (2000). Constructivist learning environments in a crossnational study in Taiwan and Australia. *International Journal of Science Education*, *22*(1), 37-55.

American Association for the Advancement of Science (AAAS) (1993). *Benchmarks for science literacy*. New York: Oxford University Press.

An, S., Kulm, G., & Wu, Z. (2004). The pedagogical content knowledge of middle school mathematics teachers in China and the U.S. *Journal of Mathematics Teacher Education, 7*, 145-172.

Astiz, M.F. (2006). Policy enactment and adaptation of community participation in education: The case of Argentina. In D.P. Baker & A.W. Wiseman (Eds), *The Impact of Comparative Education Research on Institutional Theory* (pp. 305-334). Oxford, UK: Elsevier.

Bianchini, J. A., & Cavazos, L. M. (2007). Learning from students, inquiry into practice and participation in professional communities : Beginning teachers' uneven progress toward equitable science teaching. *Journal of Research in Science Teaching*, *44*(4), 586–612.

Blömeke, S. & Paine, L. (2008). Getting the fish out of the water: Considering benefits and problems of doing research on teacher education at an international level. *Teaching and Teacher Education*, *24*, 2027-2037.

Bogdan, R. C., & Biklen, S. (2007). *Qualitative research for education: An introduction to theory and methods*. Needham Heights, MA: Allyn & Bacon.

Buchmann, C., & Parrado, E.A. (2006). Educational achievement of immigrant-origin and native students: A comparative analysis informed by institutional theory. In D.P. Baker & A.W. Wiseman (Eds), *The Impact of Comparative Education Research on Institutional Theory* (pp. 335-361). Oxford, UK: Elsevier.

Chisholm, L., & Leyendecker, R. (2008). Curriculum reform in post-1990s sub-Saharan African. *International Journal of Educational Development*, *28,* 195-205.

Cochran-Smith, M., & Fries, K. (2005). Researching teacher education in changing times: Politics and paradigms. In M. Cochran-Smith & K.M. Zeichner (Eds.) *Studying Teacher Education* (pp. 69-109). Mahwah, NJ: Lawrence Erlbaum.

Council of Chief State School Officers [CCSSO] (2011). *InTASC model core teaching standards: A resource for state dialogue*. Washington, DC: Author. Retrieved from http://www.ccsso.org/Resources/Publications/

Davies, S., & Aurini, J. (2006). Rethinking 'macro' and 'meso' levels of institutional analysis: The case of international education corporations. In D.P. Baker & A.W. Wiseman (Eds), *The Impact of Comparative Education Research on Institutional Theory* (pp. 121-136). Oxford, UK: Elsevier.

Feiman-Nemser, S. (2001). Helping novices learn to teach: Lessons from an exemplary support teacher, *Journal of Teacher Education, 51*(1), 17-30.

Findlay, M., & Bryce, T. G. K. (2012). From teaching physics to teaching children: Beginning teachers learning from pupils. *International Journal of Science Education*, *34*(17), 2727–2750.

Fraser, B.J., Aldridge, J.M., Adolphe, F.S.G. (2010). A cross-national study of secondary science classroom environments in Australia and Indonesia. *Research in Science Education, 40*, 551-571.

Forbes, C.T. (2004). Peer mentoring in the development of beginning secondary science teachers: Three case studies. *Mentoring & Tutoring: Partnership in Learning, 12*(2), 219-239.

Hoadley, U., & Jansen, J. (2009). *Curriculum: Organizing knowledge for the classroom Second edition.* Cape Town, South Africa: Oxford University Press Southern Africa.

Johnson, C.C. (2013). Educational turbulence: The influence of macro and micro-policy on science education reform. *Journal of Science Teacher Education, 24*(4), 693-715.

Lawrenz, F., Huffman, D., Appeldoorn, K., & Sun, T. (2002). *CETP core evaluation, classroom observation handbook.* Minneapolis, MN: CAREI.

Lee, E., Brown, M. N., Luft, J. A., & Roehrig, G. H. (2007). Assessing beginning secondary science teachers' PCK: Pilot year results. *School Science and Mathematics, 107*(2), 52-60.

Leite, L., Mendoza, J., & Borsese, A. (2007). Teachers’ and prospective teachers' explanations of liquid-state phenomena: A comparative study involving three European countries. *Journal of Research in Science Teaching*, *44*(2), 349–374.

Lindemann-Matthies, P., Constantinou, C., Lehnert, H., Nagel, U., Raper, G., & Kadji-Beltran, C. (2011). Confidence and perceived competence of preservice teachers to implement biodiversity education in primary schools – four comparative case studies from Europe. *International Journal of Science Education, 33*(16), 2247-2273.

Little, J.W. (2003). Inside teacher community: Representations of classroom practice. *Teachers College Record*, *105*(6), 913-945.

Loughran, J. (1994). Bridging the gap: An analysis of the needs of second-year science teachers. *Science Teacher Education, 78*(4), 365-386.

Luft, J. A., Dubois, S.L., Nixon, R.S., Campbell, B.K., & Bang, E. J. (in review). Newly hired teachers of science: A review of research. *Studies in Science Education.*

Luft, J.A. (2009). Beginning secondary science teachers in different induction programmes: The first year of teaching. *International Journal of Science Education, 31*, 2355-2384.

Luft, J.A., Firestone, J.B., Wong, S.S., Ortega, I., Adams, K., & Bang, E. (2011). Beginning secondary science teacher induction: A two-year mixed methods study. *Journal of Research in Science Teaching, 48*(10), 1199–1224.

Lynch, S., Pyke, C., & Jansen, J. (2003). Deepening understanding of science and mathematics education reform principles: Novice teachers design web-based units using Project 2061's curriculum analysis. *Journal of Science Teacher Education, 14*(3), 193-216.

McGinnis, J.R., Parker, C., & A.O. Graeber. (2004). A cultural perspective of the induction of five reform-minded beginning mathematics and science teachers. *Journal of Research in Science Teaching, 41*(7), 720–747.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Jossey-Bass.

Meyer, J.W. (1977). The effects of education as an institution. *American Journal of Sociology, 83,* 55-77.

Meyer, J.W., Boli, J., Thomas, G., & Ramirez, F. (1997). World society and the nation-state. *American Journal of Sociology, 65,* 128-149.

Miles, M.B., Huberman, A.M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook*. Los Angeles, CA: SAGE.

Powell, R. P. (1997). Teaching alike: A cross-case analysis of first-career and second-career beginning teachers' instructional convergence. *Teaching and Teacher Education, 13*(3), 341–356.

Republic of South Africa Department of Higher Education and Training [DHET] (2011). *The Minimum Requirement for Teacher Education Qualifications.* Pretoria South Africa: The Government Printing Works.

Roehrig, G.H., Kruse, R.A., & Kern, A. (2007). Teacher and school characteristics and their influence on curriculum implementation. *Journal of Research in Science Teaching, 44*(7), 883–907.

Roehrig, G.H., & Luft, J.A. (2004). Constraints experienced by beginning secondary science teachers in implementing scientific inquiry lessons. *International Journal of Science Education 26*(1), 3-24.

Saldaña, J. (2013). *The coding manual for qualitative researchers.* Los Angeles, CA: SAGE.

Schneider, R., & Krajcik, J. (2002). Supporting Science Teacher Learning: The Role of Educative Curriculum Materials. *Journal of Science Teacher Education, 13*(3), 221-245.

Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and the social sciences.* New York, NY: Teachers College.

Shen, J., Gerard, L., Bowyer, J. (2010). Getting from here to there: The roles of policy makers and principals in increasing science teacher quality. *Journal of Science Teacher Education, 21*(3), 283-307.

Smith, L. K., & Southerland, S. A. (2007). Reforming practice or modifying reforms?: Elementary teachers’ response to the tools of reform, *44*(3), 396–423.

Tatto, M.T. (2006). Education reform and the global regulation of teachers’ education, development and work: A cross-cultural analysis. *International Journal of Educational Research, 45*, 231-241.

Williams, J., Eames, C., Hume, A., & Lockley, J. (2012). Promoting pedagogical content knowledge development for early career secondary teachers in science and technology using content representations. *Research in Science & Technological Education*, *30*(3), 327-343.

Windschitl, M., Thompson, J., & Braaten, M. (2011). Ambitious pedagogy by novice teachers: Who benefits from tool-supported collaborative inquiry into practice and why? *Teachers College Record*, *113*(7), 1311-1360.

Wiseman, A.W., & Baker, D.P. (2006). *The impact of comparative education research on institutional theory*. Oxford, UK: Elsevier.

Wong, S., Firestone, J., Luft, J.A., & Weeks, C. (2013). Beginning secondary science teachers’ laboratory practices: A five-year study. *Science Educator*, 22(1), 1-9.

Zembal-Saul, C., Blumenfeld, P., & Krajcik, J. (2000). Influence of guided cycles of planning, teaching, and reflection on prospective elementary teachers’ science content representations. *Journal of Research in Science Teaching*, *37*(4), 318-339.

Appendix A

Questionnaire

1. This is your _______________ year of teaching.
2. What is your race/ethnicity?
3. What is your gender?
4. What is your age?
5. Which of the following best describes your highest degree? (subject)
6. Which of the following best describes your highest degree? (level)
7. Which of the following best describes how you become licensed/certified as a teacher?
8. Briefly describe your science content coursework.
9. How useful were these courses for your teaching?
10. Briefly describe experiences you had in classrooms as a preservice teacher.
11. How useful were these experiences for your teaching?
12. Briefly describe your teaching methods/pedagogy coursework.
13. How useful were these courses for your teaching?
14. Briefly describe your student teaching experience.
15. How useful was this experience for your teaching?
16. What courses did you teach during student teaching?
17. Which country do you teach in?
18. How many teachers at your school hold governing body posts?
19. Is this your first career?
    a. What was your previous career?
20. How many classes do you teach this year?
21. What is the grade level of students in your Class 1?
22. What is the course/subject of Class 1?
23. How many students are in Class 1?
24. What is the grade level of students in your Class 2?
25. What is the course/subject of Class 2?
26. How many students are in Class 2?
27. What is the grade level of students in your Class X?
28. What is the course/subject of Class X?
29. How many students are in Class X?
30. Do you have a laboratory assistant to help prepare your science investigations?
31. Do you have access to lab kits for your instruction?
    a. If yes, which kits?
32. Which of the following best describes your classroom situation?
    a. (with lab or not)
33. Which of the following best describes your classroom situation?
    a. (own classroom?)
34. What type of materials to teach science are in your classroom/school? [Textbooks, Additional books, TV, Chalkboards, Whiteboards, Smart/Promethean Boards, Overhead projector, LCD projector, Proxima projector, Computers, Internet connection, Glassware, microscopes, models, safety equipment, running water, gas jets, Bunsen burners,

electricity, outlets, dedicated laboratory space/table, everyday household chemicals, specialized chemicals for science]

35. At your school, how many teachers have their own classrooms?
36. How many science teachers stay employed at your school MORE than 3 years
37. How many science teachers stay employed at your school MORE than 5 years?
38. In your opinion, why do teachers stay at your school?
39. In your opinion, why do teachers leave your school?
40. One of my responsibilities outside of teaching is:
    a. Which years have you had this responsibility?
    b. How did you come to be involved with this responsibility?
    c. Were you supervised while you fulfilled this responsibility?
    d. Did you work with a group of teachers on this responsibility?
41. Another one of the responsibilities outside of teaching is:
    a. Which years have you had this responsibility?
    b. How did you come to be involved with this responsibility?
    c. Were you supervised while you fulfilled this responsibility?
    d. Did you work with a group of teachers on this responsibility?
42. Please describe any other responsibilities you have at the school that are outside of your regular teaching duties.
43. Is there anything else about your teaching situation that you would like to tell us about at this time?

Appendix B

Contextual Pre-Interview Questions

1. How did you decide to become a science teacher?

a. Did your parents go to the college/university?

b. Can you tell me about your experience in secondary science (as a learner)? Did you experience laboratory work?

c. Was science teaching your first career choice in college/university? Or did you change your mind?

2. Have you always taught at the same school?

If not, where have you taught previously and what subjects did you teach (Interviewer fills in the chart below)? Why did you move?

Have you always taught the same subject?

If not, what have you taught previously?

Number of Years	Type of School	Subject taught	Grades taught

3. Would you please tell me about the community around the school?

a. How involved is the surrounding community in the school culture?

b. What kinds of non-school educational opportunities do students have access to in the surrounding community?

4. What kind of instructional/teaching support do you have access to at your school/district?

a. Do you have a mentor? Can you tell me a bit about your mentor?

b. Where or from whom do you get most of your instructional/teaching support (e.g., internet, colleague next door, conferences, mentor, district person)?

c. What is it that makes this support 'helpful'?

d. Has the support you have used changed over time?

5. Can you describe any professional development activities that you have participated in?

a. What about the logistics in attending these activities (e.g., paid, mandatory, on your own time, etc.)?

b. Were they useful for your classroom practice? Why or why not?

c. Were there any special workshops offered for new teachers before the school year started or during the school year?
d. If so, can you describe them?
e. If not (or In addition), what kinds of workshops would you have liked to been offered?

6. Can you describe the leadership at your school for you as a new teacher?
a. In what ways did they provide support, autonomy?
b. Can you describe the leadership roles (Principal, Heads of Departments)?
c. Elaborate on your experience with the leaders in the school (with respect to the running of the school as well as within your subject/academic department).
d. How is science viewed in the school? (valuable? high status?) Please describe.
e. Do teachers receive any recognition or awards for their teaching? Please describe.

7. Tell me about your planning to teach.
a. When, where, how, and with whom do you plan? (How long? With others or by yourself? Lesson plan format?)
b. Where do you typically obtain lessons or ideas for lessons?
c. Is the format of your planning uniformly practiced by the school or is it your way of planning?
d. Is collaboration important in your department/school? Please explain.
e. How do you decide what to teach or what not to teach?
f. How do you incorporate what you know about your learners into your planning?

8. What kinds of resources and materials are available to you in your planning (e.g., standards & other guiding documents, curriculum person, resource center, online websites)?
a. How does the physical nature of your classroom influence your planning (opportunities, constraints)?
b. Anything from the community?

9. How do you decide what and how to assess in your classes?
a. Why do you assess?
b. What types of assessments do you typically use? How often do you use these assessments?
c. Do you assess student prior knowledge? Why or why not?
d. Do you assess student progress during a unit? If so, how?
e. Does knowledge gained from assessment impact your instruction? If so, how?
f. Do you have common assessments in the school, or district? If so, what are these tests and how often do you use these?

10. Tell me about the learners in your classes.
a. How far do your learners travel to school? (most are close by, most travel by public transportation or school transportation?
b. Are most learners from this area?
c. How well are your learners prepared for your class?
d. What languages are spoken at home? What is the language of instruction in your class?

e. What are their home environments like? (Is there a place for them to do homework? Are parents or guardians typically around?)
f. Tell me about how learners behave in your science class. Why do you think this is so?
g. Tell me about learners' attitudes towards science class. Why do you think this is so?

11. Is there anything else that you would like to tell me that is important to this study that I have not asked you about? (e.g., colleagues, culture, feeling underprepared)

Appendix C

Post-Interview Questions

1. Tell me about the lessons.

a. Where did the lessons come from?
b. What did you consider when planning these lessons?
c. What resources did you draw upon in preparing these lessons (e.g., materials, people)?
d. Did the lessons go as expected, or not? Please explain.
e. What changes did you have to make in the lesson, as you were teaching the lesson, which were unexpected?
f. Did you have to do any improvising during these lessons? Please describe.

2. If you teach this lesson again, what would you do differently? Why?

3. Can you tell me how well the lessons supported student learning?

a. Did the students learn the concepts you were hoping they would?
b. Did you assess student's prior knowledge at the beginning of the lesson? If so, how?
c. Did you gauge student progress during the lesson? If so, how? Did this inform your instruction? If so, how?
d. What parts of the lesson supported student learning specifically?

4. Do you have any other thoughts about the lessons?

5. Tell me about the science content you have been teaching.

6. Have you learned over the year(s) as a science teacher? If so, in what ways?

7. Have you changed over your year(s) as a science teacher? If so, in what ways?

8. Are there components of your science teaching that you have spent some time thinking about? How do you give attention to these?

9. Is science important to learn? Why or why not?

10. Can students take the science they learn in your class and apply it to their everyday lives? Please explain. Can you give any examples?

11. Are there any other things you would like to talk about that we have not already discussed?

Appendix D

Code Book

Thematic Codes

---

01. Content – *All comments relating to the content. This will include comments on how the content is taught, how it is explained or any other relating comments.*

Node	Sub-Node	Definition
Defining science words		Any mention where scientific words or terms are defined
Explaining content	Inaccuracy of content	Comments relating to the inaccuracy of explanations or instances where the teacher's content knowledge is challenged
	Using examples	Comments relating the use of examples to explain the content
Relating to the topic	Balancing equations	All content relating to the content taught for balancing equations
	Chemical bonding	All content relating to the content taught for chemical bonding
	Solutions	All content relating to the content taught for solutions
	Acids and bases	All content relating to the content taught for acids and bases
	Formulas	All content relating to the content taught for empirical and molecular formulas

02. Culture – *Discussion of any cultural components that arise during the coding process. These are mostly comments or instances that reflect South African or United States cultural components of teaching.*

Node	Sub-Node	Definition
Using cultural examples		Any type of example a teacher uses that is cultural. E.g., kool-aid as a mixture, antifreeze, Mardi Gras, iron in food
Involving people	Teachers	Comments that reflect the culture of teaching regarding teachers. E.g., addressing teachers
	Students	Comments that reflect the culture of teaching around students. E.g., allowing students to listen to music during class, calling learners by name
Teaching	Science teaching	Comments that reflect the culture of science teaching. E.g., the expectation to do labs, lab practicals
	General teaching	Comments that reflect the general culture of teaching. E.g., time structure, homework assignment

03. Instruction – *Comments and discussion of beginning science teachers' instruction. Can range from the strategies, to using student input, to managing the classroom space, to focus on testing.*

Node	Sub-Node	Definition
Instructional strategies	Specific strategies listed	Any mention of an instructional strategy used that is not already coded in the five minute increments
Using student input	Student participation	Instances where it is clear the students were actively engaged and participating in the lessons.
	Student questions	Specific questions asked by students during the instruction.
	Student feedback	Any instance where the teacher bases instruction on student feedback. E.g., the students perform what was expected
Managing the classroom space	Time and space	During instruction, any mention of time or space components of teaching. E.g., interruptions, time management
	Students	During instruction, any mention of the management of students. E.g., classroom management, monitoring student progress, keeping students on task
Five minute increments		From the five minute coding procedure used in the observations

04. Planning – *Discussion of beginning science teachers' planning process. Can range from the planning format, to what was considered when planning, to the types of resources used.*

Node	Sub-Node	Definition
Using Resources	Social resources	Can be anyone human the teacher uses for resources. E.g. colleagues, university faculty, staff members at the school, technology person
	Content resources	Resources the teacher uses for content specifically. E.g., internet, websites, videos
	Developing resources	When the teacher indicates any part of the lesson plan was self-created
	Physical resources	Any mention of the physical materials used when planning. E.g., models, internet, projectors
Considering when planning	Students	Anything regarding the consideration of students when planning. E.g., student ability, student diversity, student interest
	Curriculum	When the teacher refers specifically to the curriculum as guiding the planning process or any mention of the planning content being driven by assessments
	Differentiation	When a teacher specifically refers to modifying, developing, or adjusting plans to account for individual student learning differences. E.g., planning extra

		activities, scaffolding instruction
Planning format	Structure	Logistical statements about the structure of planning. E.g., meeting schedule, meeting format
	Collaborative	When the teacher mentions anything regarding collaboration during planning. It can also mean the lack of collaboration. E.g., we are supposed to collaborate, but we do not.
	Individual	Any type of teacher autonomy with planning. E.g., one plans individuals, freedom with pacing, choices

05. Reflecting – *Comments or discussion of the reflection of beginning science teachers. Reflection can be on the other categories, or different areas.*

Node	Definition
On instructional strategies	Any reflection on general teaching strategies. E.g., would do something different with the video, would plan for stations next time, need for collaborative groups
On science instructional strategies	Any reflection on science specific teaching and/or science teaching strategies. E.g., the teacher would like to do more labs, having the students take actual measurements next time, believing a teacher should not give direct instruction in science
On student learning	Any reflection on student learning or how students learn science
On content	Any reflection on the specific chemistry content taught. E.g., spending more time on a concept, teaching a specific concept
On planning	Any reflection on the planning process used in the lessons
On support	Any reflection on the support teachers have received
Unproblematic reflection	If a teacher indicates the lesson went as expected. No problems were experienced

06. Student learning – *This includes the teacher's thinking around student learning as well as instances of student learning in the classroom.*

Node	Sub-node	Definition
Focusing on students		Teacher comments showing that they are thinking about the students and how/if they would learn. Also instances where the teacher is thinking about the students and how this impacts their decision-making
Supporting student learning		Teacher mentioning specific approaches to help students learn
Teacher view of student learning	Constraints	Teacher comments on things that limits student learning
	Enablers	Teacher comments on things that enables or assists or encourages student learning

07. Support – *This includes discussion of the variety of support and professional development programs a beginning science teacher receives or desires, as well as the types of support these programs provide.*

Node	Sub-node	Definition
Mentoring	Administrative role	Teacher commenting on admin support provided by the mentor, e.g. where to photocopy, logistics in the school
	Career guidance	Comments relating to the mentor considering the career development of the mentee
	Content support	Mentors providing resources, labs, worksheets, guidance on content, how to do a lab, etc.
	Emotional support	Teacher commenting on the mentor providing emotional support, e.g. motivation, helping when she can't cope, grading tests when he does can't get to it, etc. When the mentor thought about the teacher as a person.
	Need for mentoring or support	Where the teacher expresses the need for mentoring especially when a mentor is no longer allocated, (e.g. 2nd or 3rd year) or in a role which the mentor is not fulfilling currently (e.g. content support) or the need for additional support in general
People support	Colleagues	Support from other teachers in the same school, or science teacher at another school, and/or principals/administrators
	Curriculum group	Support specifically from a science curriculum group (e.g swop and share in SA, or chemistry curriculum group in US)
	District	Support from the district, either through individual, or event organized by the district
	Professional organizations	Support organized by professional organizations, e.g NAPTOSA in SA
	Self	When the teacher felt that they had to do it themselves, e.g. prepare lessons, etc. often because they prefer to do it by themselves, or the situation at the school required this.
	Tertiary institutions	Support from university lecturers, or others at tertiary institutions, e.g. college professors
Professional development	Conference	Teachers identify the attendance of a conference as a PD opportunity.
	Desired PD topics	Various topics teachers mention that they would like to be included in future professional development activities. (i.e. topics or issues not addressed at PD opportunities they had, and which they felt they need PD on)
	For new teachers	PD opportunities specifically for new teachers

	Not science specific	PD on topics which is not related to science, e.g. motivation, personality identification, classroom management
	Science specific	PD on topics which is related to science
	Usefulness of PD	Teachers' comments on the usefulness of the PD which they have been part of
Providing support and leadership		When the teacher starts taking on roles of support to other newer teachers, or when leadership responsibilities are allocated to teachers
Types of support	Administrative support	Support involving logistics, and other administrative issues at a school
	Content support	Support relating to the content that is taught. E.g people helping explain the content
	Emotional support	Support relating to the teacher as a person
	Instructional support	Support relating to the teaching of the content, e.g. lesson observations
	Structural support	Support relating to the things the school or district has put in place to help new teachers, e.g. less load, classroom near other science teachers, availability of resources, equipment, lab technician, internet, etc.

08. Teacher Knowledge – *This includes all comments regarding teacher knowledge.*

Node	Sub-node	Definition
Of Content	Making content relevant	Instances where the teacher wants to make the content more relevant to their students, e.g. by choosing relevant examples.
	Representing content	Instances where the teacher shows knowledge of different ways in which the content can be represented
	Transforming content	Teacher's comments on changing the content to make it understandable to students
Of Context	Dealing with contextual constraints	Comments on how teachers handle the limitations or constraints of the environment they work in, e.g. lack of resources. Also include where teachers have no contextual constraints and they are aware of it.
Of Curriculum	Curricular saliency	Comments on placing the topic in the curriculum, what goes before, what goes after, the order in which to teach topics and sub-topics. Also where the teacher shows knowledge about what is in the curriculum for the topic for their grade as well as other grades.
	Evaluating the curriculum	Teacher engaging with the curriculum and making decisions about the implementation of it
Of Students	Knowing the	Comments where the teacher shows that he/she

	students	knows the students, where they are from, what they like, e.g. who likes cars, who uses drugs, who is motivated to learn, etc.
	Student attitudes	Teacher's comments on what the students think and do, e.g they don't work outside of school
	Student difficulties	Areas where the students struggle, e.g. algebra, working with solubility curves, etc.
	Students diversity	Comments of the difference/diversity amongst students in a class, sometimes liked to the challenges it poses for teaching
	Student prior knowledge	References to what the students know about a topic before it is taught (not what they need to know, but what they actually know)

09. Teacher Learning – *Discussion of how beginning teachers have learned over time and what they have learned.*

Node	Sub-Node	Definition
Of content	Transforming content	When a teacher indicates s/he has learned how make science content understandable to secondary learners.
	From student questions	Any instance where it is evident the teacher is learning based upon student input and questions from class.
	From curriculum materials	Any instance where the curriculum materials are educative to the teacher as well in terms of content. This means the teacher learned content through the teaching curriculum.
Of students	Diversity	Instances when the teacher has learned more about the diversity of students. Particular comments regarding the diversity of students and how they learn.
	Student thinking	Instances when the teacher learns more of the thinking of his/her students. Particular comments on what the teacher has learned regarding student thinking.
Of science instruction	Instructional strategies	Instances where the teacher indicates learning on instructional strategies. E.g., collaborative groups, making more of an engaged introduction to the lesson
	Science teaching is cross-discipline	Instances where the teacher has learned that teaching science also involves teaching math, or another subject.
	Classroom management	When the teacher indicates learning of classroom management.
Of teacher role	Characteristics	Instances when the teacher indicates s/he has learned more of the internal characteristics of teachers. E.g., becoming more patient, building confidence, goal oriented
	Professionalis	Instances when the teacher refers to the learning

	m	continuum of teachers. That a teacher never stops learning, and indicates s/he is consistently ready to learn.
Of planning	Importance of planning	If a teacher reflects on the importance of preparing and/or planning for a lesson.
	Using the curriculum	
Of resources		Learning about resources – physical, social, etc.

10. Teacher Views – *This includes the teacher's view (beliefs and knowledge) on science and science teaching.*

Node	Sub-Node	Definition
Science	Science is important to learn	Teacher's comments on/reasons why science is important to learn. E.g., analytical way of thinking, career focus, changing nature of science, science is everywhere
	Science is problem solving	Teacher's view on what science is
	Tentative nature of science	Teacher's view on the nature of science
	How students learn science	Teacher's view on how students learn science (E.g., through laboratories, looking in the textbook)
Science teaching	Teacher role	Comments on the role of the science teacher when teaching the subject, E.g you need to be a motivator, not let learners waste time, encourage student curiosity
	Topics that students can apply to their everyday lives	Teacher identifying topics that students can use in their daily lives.
	Topics that students cannot apply to their everyday lives	Teacher identifying topics that students cannot use in their daily lives.

CHAPTER 4

NEWLY HIRED TEACHERS OF SCIENCE: A REVIEW OF REASEARCH IN THE FIELD[3]

[3] Luft, J.A., Dubois, S.L., Nixon, R.S., Campbell, B.K., & Bang, E.J. Submitted to *Studies in Science Education, 1/31/14*

Introduction

Newly hired teachers, recent graduates, or beginning teachers have captured the interest of teacher educators and policy makers. For teacher educators who work primarily with teachers seeking their initial certification or licensure, they follow local guidelines that ensure teachers have the prerequisite knowledge and practices needed for effective instruction and ongoing professional learning. Some teachers, however, do not enroll in an initial certification program and just progress to being newly hired. For policy makers, newly hired teachers are potential sources of data about the rigor and adequacy of an initial teacher preparation program or about the process of certifying teachers. The students of newly hired teachers, in particular, can provide data that reveal the adequacy of the different pathways to becoming a teacher.

Aside from the outcomes valued by teacher educators and policy makers, understanding the development of newly hired teachers offer insights into a learning trajectory of science teachers. Feiman-Nemser (2001) suggested a potential trajectory for early career teachers, which addressed the development of important knowledge bases and instructional practices on time. Luft (2012) revised this trajectory to explicitly state the content knowledge that a teacher should learn and know, and also offered a potential model explaining how newly qualified teachers came to understand their teaching of science. In the model presented by Luft (2012), there was an emphasis on working in a classroom to build one's knowledge to teach.

The purpose of this review is to explore research over the last thirty years as it pertains to newly hired teachers of science (NHTS). In this study, NHTS are elementary and secondary teachers of science, who are in their first through fifth year of teaching science with learners in a classroom. By using the term *newly hired*, we point to the recent trend in education to hire new teachers who may not have engaged in a qualification or certification program.

From this review, we suggest what is known about NHTS, explore general trends pertaining to NHTS, and examine the research as it pertains to supporting central areas important in teacher growth and development. This review also provides insights into the needed research in this area of NHTS. From this review, we hope that science teacher educators will contemplate how they prepare and support their NHTS.

Prior Research Reviews

This review of research focuses on NHTS. These teachers are in their first to their fifth year of teaching and in their first careers as teachers. Some scholars may consider the term NHTS to be synonymous with the discussion of the induction process among teachers. In this review, we acknowledge the varied meanings of induction, as discussed by Feiman-Nemser (2010), which includes a phase in learning to teach, a program to support and mentor beginning teachers, and a process of socialization. These areas emerge in the analysis of literature. We also point out that this review also focuses on a specific time in the career of a teacher. With this perspective, prior research focused on induction as well as newly hired teachers, is important to this synthesis.

To begin with, published reviews on induction and beginning teachers have been both general and science-specific. Ashby et al. (2008), Gold (1996) and Wang, Odell, and Schwille (2008) offer the most robust general reviews about beginning teachers. We should add that we excluded Ingersoll and Strong (2011) because of their bias towards comparative studies, which limited important research in the field.

The general review of induction by Ashby et al. (2008) focused on the experiences of early career teachers, including those in their induction years. This review drew primarily upon studies from the United Kingdom (UK), but it also contained studies from other countries. Most of the findings were descriptive and shared the experiences of induction teachers. Sections in the review addressed the transition to a first-year teacher, the impact of induction arrangements on newly qualified teachers, the new teacher mentor, and positive and negative experiences of first year teachers. Ashby et al. (2008) recognized the importance of the induction process, and called for additional research that connected initial training to induction.

Gold's (1996) review focused on beginning teacher support as it pertained to attrition, mentoring and induction programs. Her review drew primarily from studies in the United States (US) and highlighted the different factors that contributed to teacher attrition, which consisted of the public perception of teachers to the complex issue of teacher burnout. One way, she suggested, to thwart teacher attrition was to provide 'support' to new teachers. This assumption guided her discussion of the support needed by new teachers and the structure of potential support programs. Within her discussion of programs, she emphasized the importance of mentor teachers and recognized others who provide support to new teachers. From her review, she suggested that there was a need for additional studies into the different approaches that can support new teachers, the 'imprinting' of new teachers, and a better understanding of how beginning teachers learn.

Wang et al. (2008) also examined primarily US research. However, their review focused on the effects of teacher induction programs on beginning teachers. Their comprehensive examination focused on the effects of a mentor within an induction program, beginning teacher experiences within induction programs, and the effects of various components of teacher induction programs on newly hired teachers. From the review, Wang et al. (2008) suggested that different methodological and conceptual approaches are important in understanding the field of teacher induction. For instance, they called for more qualitative studies that explored the abilities of mentors, comparative studies that explored teacher development, and a wide variety of studies that explored how beginning teachers interface with different contexts (e.g., school, induction programs).

Ashby et al. (2008), Gold (1996) and Wang et al. (2008) recognized the complexity of the teacher induction process. All also emphasized the role of the mentor within an induction program. Gold (1996) and Wang et al. (2008), however, found the need for additional research in the area of mentoring, and in the socialization process of new teachers. Finally, all suggested that more research was needed that pertained to new teacher learning. For Ashby et al. (2008) this entails understanding how initial certification prepares teachers for their first years in the classroom. For Wang et al. (2008) this specifically involves examining the development of new teacher content knowledge.

For science-specific reviews pertaining to new educators, Davis, Petish, and Smithey (2006) and Bianchini (2012) conducted comprehensive literature reviews. Davis et al. (2006) examined studies between 1993-2004, which focused on preservice teachers through teachers in their fifth year of practice. Bianchini (2012) examined the literature from 1998-2010, and drew upon research that focused on teachers in their first three years of teaching. While both reviews included elementary and secondary teachers, the conclusions offered by each review were different.

The analysis of literature conducted by Davis et al. (2006) was guided by the Interstate Teacher Assessment and Support Consortium (InTASC) standards (Council of Chief State School Officers ([CCSSO], 2002) and the *National Science Education Standards* (NSES) (National Research Council ([NRC], 1996). These standards framed the discussion of the selected studies into four broad areas: content, learners, instruction, learning environments, and professionalism. From their review, they found several challenges for new science teachers, and they found areas that support the development of new science teachers. For instance, they found that science coursework and preservice teacher education programs contributed to the instruction and learning of teachers in their first few years, but concluded that there were few studies that examined how induction and professional development programs could support the learning and instruction of NHTS. They concluded their review with several recommendations, including future research that examines beginning teachers' understanding of the reforms and how they teach the reforms, and future research that explores early career teacher development.

Bianchini's (2012) analysis of research addressed several areas. These areas consisted of the transition of beginning science teachers from their initial preparation program to the first years in a classroom, the impact of induction programs on new teachers, the role of context in new teacher development, and the agency of new teachers. Among these studies, Bianchini (2012) emphasized the importance of school context and teacher education programs on new teacher development. She added that studies examining beginning teachers were more common than studies that look at school context. Bianchini (2012) recommended that future research follow teachers through several years in the classroom, and that research studies in this area clearly state a theory of teacher learning.

General and science-specific scholarly reviews of new teachers focus on programs (Gold, 1996; Wang et al. 2008), on induction as a phase in learning to teach (Ashby et al., 2008; Davis et al. 2006), and on the process of socialization (Bianchini, 2012). Within these reviews there are important conclusions. First, the earliest review (i.e., Gold, 1996) focused on induction programs to provide psychological support for beginning teachers, whereas more recent reviews (i.e., Bianchini, 2012) considered the external factors of school context that undeniably influences beginning teacher learning. Second, there is an increased focus on the connection of induction and policy over time. Ashby et al. (2008) and Gold (1996) explicitly mentioned the impact of policy on induction programs, while Davis et al. (2006) arranged the entire review around policy standards. Third, there has been increased attention to beginning teacher learning. Ashby et al. (2008) and Davis et al. (2006) called for more studies about the learning of new teachers, while Wang et al. (2008) and Bianchini (2012) called for more studies that connect beginning teachers' practices to student learning.

Research Trends Over Time

The study of NHTS has received increased attention in recent years. Among the articles selected for this review, only one article was published in the 1980s. The 1990s saw a substantial increase in research on NHTS with 22 selected publications. From 1990 onward, research on NHTS increased by approximately 0.4 additional published articles each successive year. This increase contributed to 93 studies that were published from 2000 and onward, with six to nine articles published each year for the last two decades. Figure 2 shows how the number of published articles has increased over time.

[Insert Figure 2 About Here]

Over time, there have some notable trends. First, there are an equal number of studies on elementary and secondary teachers. Although, initially most of the studies focused on secondary teachers, then there was a preponderance of studies focused on elementary teachers. More recently, an equal distribution of studies has been published on both elementary and secondary teachers. Second, most of the studies were quantitative, and now there are more qualitative studies. Finally, content knowledge has been a focal area over time.

Studies Used in this Review

This review of research spans 30 years, and begins in 1982 and ends in 2012. This period of time captures the increased attention to NHTS by educational researchers. Articles included in this review were found by selecting journals in two different ways. First, we selected top-ranking, peer-reviewed science education journals that were published throughout the time period of interest. This resulted in the selection of the *European/International Journal of Science Education*, *Journal of Research in Science Teaching*, and *Science Education*. Second, we identified ten education journals with the highest impact factor ratings. Out of these ten journals we selected journals that would potentially include articles about NHTS (i.e., not explicitly focused on areas outside of science education). This resulted in the selection of *American Educational Research Journal*, *Journal of the Learning Sciences*, and *Learning and Instruction* for inclusion in our review.

The articles selected from these journals had to include full-time NHTS in the participant pool, or they had to focus on teaching science (in the case of elementary teachers or experimental studies). In having this focus, each identified article needed an approximately equivalent number of participants to be NHTS, or there had to be a clear focus on understanding NHTS. For instance, a study with one NHTS and three experienced teachers was not included in the review unless the study focused on science teacher development. Ultimately, if the study had an appropriate number of NHTS, the study focused on understanding some aspect of NHTS, or if the study was about the transition from preservice education to the first years of teaching science, then the article was included in the pool to review.

The identified articles were placed in Dropbox, and a spreadsheet was created to briefly describe each article. In the spreadsheet, the title, journal, date of publication, article descriptors (if provided) and author(s) were noted. In addition, we recorded the methodological approach, the size of the population, and the grade band in the study. Finally, a system was created that allowed us to tag up to three areas of emphases of each article, and include a brief statement about the findings and methodological approach.

With the information from the spreadsheet, a second search was conducted through ERIC/EBSCO host. The descriptors that were noted in the spreadsheet were used for a second search of peer-reviewed articles that specifically focused on NHTS. By focusing specifically on NHTS, our search terms aligned with this population, and we used the term ‘science’ along with: beginning teacher(s), induction teacher(s), beginning elementary teachers, newly qualified teacher(s), mentoring, mentors, novice teacher, and new teacher(s). We specifically searched the abstracts of peer-reviewed articles for these terms. This second search identified several articles outside of our hand search.

In order to gauge the research quality of each publication, we referred to the guidelines by the American Educational Research Association (AERA) (AERA, 2006) for research publications, and guidelines for reviewing older research by Bybee (1982). We also reviewed the criteria used in Clarke, Triggs, and Nielson (2013) review of research. Drawing upon these resources, we created a rubric to evaluate of the identified articles. The rubric criteria consisted of (1) a clear research question and focus, (2) appropriate methodological approaches and tools, (3) claims consistent with and supported by data, and (4) the contribution to the literature. Table 3 is the rubric that was used to evaluate each article. Articles that scored a 0 in the area of Design and Procedures, or Results and Discussion were eliminated immediately. A 0 in these areas signified either no methodological orientation, or a limited or missing analysis. Articles without a 0 in these areas needed a total score of 2 or more in order to be included in this review.

[Insert Table 3 About Here]

This process of searching resulted in 174 articles, from which 108 were used in this review. Reviewed articles were published in 27 journals, but predominantly originated from five journals: *Research in Science Education* (5 articles), *International Journal of Science Education* (9 articles), *Journal of Science Teacher Education* (17 articles), *Science Education* (18 articles), and *Journal of Research in Science Teaching* (30 articles). An additional 22 journals provided from one (most common) to four articles each.

Most of the identified articles were from the US, although there was a significant number of studies were published by researchers from the UK and Australia. In this article, studies that are not from the US are noted in the description of the research.

Teacher Education Standards – An International Framework

In order to guide the analysis of the identified articles, teacher professional standards were examined from different countries. The standards selected had clear language regarding newly qualified, newly hired, or induction teachers, or they were used in a national setting to guide newly qualified teacher evaluation or comprehensive induction programs for NHTS. The standards examined included the *Teachers' Standards* from England (Department of Education, 2012), the *Australian Professional Standards for Teachers* (Australian Office for Teaching and School Leadership [AITSL], 2013), the *Teacher Performance Appraisal Technical Requirements Manual* (Ontario Ministry of Education, 2010), the *Graduating Teaching Standards: Aotearoa New Zealand* (New Zealand Teachers Council, 2007), and the *InTASC Model Core Teaching Standards* (CCSSO, 2011) in the US. All of these documents were accessed online.

The documents were examined in order to determine emphasized areas within the different international standards. An area of emphasis was noted when there were standards or subareas across all five selected documents. As matching the exact wording of a standard to determine an area would be difficult, the broad meaning of the standard or subareas was the focus of the analysis. For instance, Part One, area 5 of England's *Teachers' Standards* (Department of Education, 2012) stated that teachers should "Adapt teaching to respond to the strengths and needs of all pupils." The items listed underneath this area were examined with this statement in mind, and then coded as emphasizing professional practice, equity, learners, or learning. These coded statements were grouped, which formed the emphasized areas.

At times, some standards and subareas were not easily coded or they consisted of areas that did not fall into the emerging areas. For instance, the *Australian Professional Standards for Teachers* (AITSL, 2013) had statements about the use of information and communication technology. Based upon the evaluation criteria supplied in the document, this subarea was ultimately placed in Professional Practice because of the emphasis on use in instruction.

Six broad areas resulted from the comparative coding process, and these consisted of: Content and Curricular Knowledge, Learners and Learning, Professional Practice/Learning Environments, Equity, Assessment, and Professionalism. Table 4 lists the areas, the standards, and gives an example standard in each area.

[Insert Table 4 About Here]

While most of the articles identified in this review did align with the six broad areas, some articles could be sorted into multiple areas, and some articles simply did not fit into these categories. To sharpen the review, articles were carefully read and placed in the area in which they made the most significant contribution. The articles that simply did not fit in a category often explored the working conditions of NHTS. Thus, this review begins with a discussion of

NHTS working conditions and then examines identified studies in the six international standard areas.

Research Outside of the Standards: Working Conditions

Research that examines the decisions and actions of NHTS gives insights into their working conditions. Some of this research reports on the persistence, movement or attrition of NHTS, while other studies describe how new teachers navigate their first years. These broad areas describe the importance of country and school context, and the motivation and resourcefulness of teachers. This area is important to examine as it is foundational for the enactment of the standards, which are discussed in the following sections.

Studies by Howe (2006), Britton, Paine, Pimm, and Raizen (2003) and Soares, Lock, and Foster (2008) examined induction programs in different countries. Britton et al. (2003) produced a book that shared induction programs in different countries, Howe (2006) crafted cases about different induction programs that were published in a journal, and Soares et al. (2008) reported on the induction of NHTS. Across all studies it is evident that countries are different in how they support new teachers. For instance, new US and UK teachers often did not have well-conceptualized and enacted systems of support. Other countries, however, created professional communities that ensured the success of new teachers. New Zealand, for example, provided assistance that included many people and ensured adequate support to teach in a content area (Britton et al., 2003). Japan and Germany provided comprehensive two-year internships that supported the learning of new teachers (Howe, 2006). These studies point to the important role that the culture of the country plays in terms of supporting new teachers. That is, some countries are oriented towards the cultivation of professional practice, while other countries are oriented towards durable educators.

Several studies reveal the importance of school or district contextual factors. Bang, Kern, Luft and Roehrig (2007), for instance, followed 115 NHTS at the secondary level over three years. Demographic data and interviews revealed that most of the teachers were still teaching after three years, with approximately 25% moving schools or leaving teaching. While there were no significant differences between the groups, there were some important trends within the groups of teachers who stayed in teaching, moved schools, or left teaching. Among the teachers who stayed in teaching, they tended to access instructional support as they planned lessons, and they interacted with colleagues about issues in teaching. Among teachers who left teaching, their decisions to leave the profession were often reported as relating to unsupportive administrators, colleagues or other district personnel. Patterson, Roehrig and Luft (2003) found similar reasons among teachers who moved schools or left science teaching. Their report on 32 teachers who participated in a science focused induction program found that 32% of teachers moved or left the profession. Primary reasons for leaving teaching pertained to dissatisfaction with the work environment, while moving to a new school pertained to finding a teaching assignment that better fit one's preparation and expertise.

In a survey of 101 second-year secondary science teachers, Alger and Norman-Gloria (2009) associated teacher morale with reasons for staying in or leaving teaching. Their sample included teachers who initially pursued a teaching career, teachers with a degree in science who became certified to teach, or teachers who were certified alternatively (e.g., short program, outside approval). It was found that alternatively certified teachers were more dissatisfied with their salary. Additionally, a decrease in the number of students in poverty in a district resulted in an increase in teacher morale.

Two smaller scale studies on NHTS report similar findings. Gilbert (2011) gathered qualitative data from two teachers, both of who had left teaching and then returned with the intention of moving on to another profession. Even though both participants saw teaching as a safe, stable profession, they discussed the social and intellectual isolation, disagreements with administrators, and testing constraints that resulted in their consideration of other career opportunities. Rinke's (2009) case study of eight NHTS in urban schools over two years had similar findings. Rinke's (2009) teachers did not intend to stay in teaching and were in the process of actively exploring alternative career opportunities. However, these teachers did want evidence that they had made a contribution to their schools before they left the teaching profession (e.g., praise from colleagues, student achievement scores, financial remuneration).

Teacher attrition is often considered to be a problem, as teachers with experience are often assumed to be more effective in terms of instruction. Henry, Fortner, and Bastian (2012) challenged this assumption in a study of 7,961 NHTS. They found the gain in teacher effectiveness, as measured by student value-added gains on a large-scale assessment, increased dramatically during the first four years of teaching. This increase is particularly notable for teachers of physics and chemistry. However, after four years of teaching experience, there were diminishing returns in terms of student performance.

For NHTS who stay in teaching, researchers are often interested in how they navigate or support themselves in their early years. Friedrichsen, Chval, and Teuscher (2007), in a study of 18 beginning mathematics and science teachers, wanted to know what structures and strategies teachers used to support themselves. Interviews revealed the use of internal and external support structures, which included school mentoring programs, beginning teacher meetings, administrators, other teachers, beginning teacher institutes outside of the school, other beginning teachers, and family and friends. Within these strategies, newly higher teachers sought advice, talked to other beginning teachers, found someone to listen, and enacted and reflected on changes in their instructional practice.

From these studies it is suggested that teachers who leave teaching do so because of workplace conditions. Isolation and challenges with administration are areas often noted by teachers who leave the profession. School administrators and teacher educators should support NHTS in handling the challenges of teaching and by creating communities that support their learning. This support will also contribute to the effectiveness of NHTS.

Another way to support NHTS can occur in their initial teacher preparation program. Teachers who are engaged in coursework to become a teacher can learn how to support themselves as they embark on their first years of teaching. This can entail learning where to find support, as well as how to engage in a productive dialogue that supports the teaching of science.

Area: Content and Curricular Knowledge

Studies in this area are focused on teacher knowledge. There are many different models and measures of teacher knowledge, and there are different purposes for the research into teacher knowledge. In reviewing the studies in this area, three broad groups of research emerged. The first group of studies described the knowledge of NHTS. Researchers who conducted these studies did not attempt to modify or influence teacher knowledge; they just reported the knowledge of teachers. The second group of studies involved interventions that were meant to improve teacher knowledge, and often the intervention was a professional development program. The third group of studies explored the influence of classroom experience on the development of teacher knowledge. These overarching areas are presented in the following sections.

Depictions of Teacher Knowledge

This group of studies depicts the knowledge that science teachers hold. In general, these studies focus on different forms of knowledge found among science teachers, which can consist of curricular knowledge, subject matter knowledge, or pedagogical content knowledge (PCK). These studies also discuss the relationship of knowledge to instructional practice. Although studies in this subarea may link to other areas, the emphasis of the studies discussed in this section is teacher knowledge.

Curricular knowledge. Several studies explored the curricular knowledge of teachers. Often this knowledge involved an understanding of guiding curricular documents, local or national curriculum, or instructional materials.

In order to better understand the gap between the reform movements and the classroom environment, Smith and Southerland (2007) investigated the knowledge of two elementary teachers about reforms. These ‘reforms’ included national standards, high-stakes testing, and the local curriculum. The two teachers were in their fourth and fifth year of teaching. Through the analysis of questionnaires, interviews, observations, the collection of artifacts, researchers concluded that the teachers were uneven in their knowledge of the reforms. Specifically, they were less knowledgeable and influenced by the national standards, and more knowledgeable and influenced by the state curriculum and high-stakes assessments.

In a study about science text use, Peacock and Gates (2000) surveyed and interviewed 23 newly qualified primary teachers in England. They wanted to understand how the primary teachers used science text in their classrooms. Text in this study pertained to a wide range of commercial and locally published books that were available to teachers, as at the time of the study there were not mandated classroom textbooks. The survey results revealed that primary teachers were not provided with information about how to use science texts to support their instruction during their preservice program or as newly hired teachers. As newly qualified teachers, the decisions they made about text use pertained to using text to help plan their lessons, using text to test the knowledge of students, and using text to extend the material presented in class. Teachers did not report using text to help in carrying out such activities as investigations, having students examine findings, or to generate discussion.

The use of text also was a focus in the study by Powell (1997). Two NHTS were the focus of this case study, which looked at their content knowledge and use of the textbook. These second career teachers taught at the secondary level. Through collected observations and documents over the course of a year, Powell (1997) constructed cases that revealed how teachers moved from different knowledge levels about science and different views about enacting science in a classroom towards a textbook centered class. While the textbook served a different purpose for each teacher, at the end of their first and third year- their views of science instruction were guided by the textbook.

Subject matter knowledge, professional knowledge, and PCK. The remaining studies in this sub-area examined the connection between various aspects of teacher knowledge and classroom practice. In some cases, the knowledge under consideration was subject matter knowledge or different types of teacher knowledge. In other instances, the knowledge under consideration consisted of PCK. To gain insights into these different knowledge bases, studies in these areas will be grouped together in this section.

In a direct assessment of subject matter knowledge, Shugart and Hounshell (1995) used the National Teachers Exam (NTE) in biology and general science to explore a potential connection in terms of content knowledge level and persistence in teaching. In this study, 83 secondary science teachers in one region who had taken the NTE in the ‘80s were categorized as never entering teaching, leaving teaching (average 4.5 years), or becoming career teachers. Their analysis took into account gender, race, and the degree granting institution. Shugart and Hounshell (1995) found that individuals with higher NTE scores were more likely than those with lower scores to never become teachers or to leave teaching. An acknowledged limitation of the study pertained to the lack of data about decisions to persist, leave, or not enter teaching.

An earlier study by Carter, Cushing, Sabers, Stein, and Berliner (1988) compared experts to novices in order to describe how they perceived and processed visual information in the classroom. The six novices (first year mathematics and science teachers), eight experts, and six postulants were shown an image or sets of images in three different tasks. An analysis of the answers of the teachers revealed differences in interpretations of classroom instruction, with the experienced teachers drawing upon a rich store of knowledge to understand the event. Experts were more cautious and contemplative in their interpretations, while novice teachers appeared hesitant and without the depth of knowledge to draw upon. Unfortunately, the nuances of science instruction are not expanded upon in this study.

Lederman (1999), in a different view of subject matter knowledge, focused on the knowledge a teacher holds about the nature of science. In his study, he explored secondary teachers’ understandings of the nature of science and the factors that potentially inhibited their teaching of the nature of science. This study used observations, questionnaires, interviews, instructional plans and materials, to examine the five biology teachers’ knowledge of the nature of science and their instruction. The analysis of data revealed the teachers’ understanding of the nature of science did not necessarily influence classroom practice, but organization and management problems did constrain their instruction.

In a different view of science, Greenwood (2003) focused on the conceptions of science that a teacher holds. In this study, three cases were constructed of third-year high school teachers who came to teaching after another career. Greenwood (2003) used questionnaires, interviews and lesson plans to understand how each teacher conceptualized science and how the teachers' conceptualization aligned with preservice coursework. The methods coursework was consistent with national reform documents. Two of the NHTS had conceptions of science in agreement with the reform documents--they had been an engineer and a biologist. The teacher who viewed science as a fixed body of facts had been in engineering management. Even though these two teachers held knowledge consistent with the reform documents, their lesson plans did not align with the reforms. In this study, one's idea about science does not directly translate into the classroom.

Beyer and Davis (2008) took a different approach to characterizing subject matter knowledge. In their study of a third-year elementary teacher, they were interested in her knowledge of scientific explanations. Observations and interviews were conducted as Catie enacted a unit on plants. The analysis of these data revealed that she held conflicting understandings of scientific explanations. She characterized explanation as an everyday term by adding details to an answer, and she characterized explanation as scientific understanding when connecting an answer to evidence. When she taught her students about explanations, she cast them in different ways and used student generated explanations to assess student knowledge. Her classroom approach to explanations came from the curriculum that she used as a teacher. This study shows the complex nature of knowledge to classroom practice.

Another form of teacher knowledge is PCK. This knowledge base is recognized as critical in transforming content knowledge into appropriate learning experiences for children, and is situated within the education domain (Shulman, 1986, 1987). Over the years, research in the area of PCK has increased dramatically and has resulted a significant number of descriptive studies (Abell, 2007; Kind, 2009). Early studies on professional knowledge contribute to what we know about PCK.

In order to understand the professional knowledge of a teacher, Munby, Cunningham, and Lock (2000) followed a Canadian 9th grade science teacher. Over a four-month period, they observed and interviewed Bess in order to understand her professional knowledge. Paying close attention to her language, they hoped to understand how she framed science and science teaching (a proxy for her professional knowledge). A thematic analysis revealed that she characterized science as fun and activity-oriented, having structure, being compartmentalized, and as focused on trying, doing and finding out. Munby et al. (2000) suggested that her knowledge of school science, as opposed to science as practiced by scientists, prevented her from involving students in the inquiry instruction.

In a different approach to understanding teacher knowledge, Alonzo, Kobarg and Seidel (2012) used video analysis to gather evidence about a teacher's PCK. The two teachers in this study were in Germany and had taught physics for three and four years. Approximately 90 minutes of video were analyzed from these two instructors in order to explore how they enacted PCK as they interacted with students. Alonzo, et al. (2012) concluded that there were differences between the two teachers. The more successful teacher, who had students with high gains in knowledge and interest in the content, used content knowledge in ways that were flexible (able to respond to student comments and challenges), rich (connected to outside experiences in ways that deepened content understanding) and learner-centered (showed awareness of students' capabilities). Alonzo et al. (2012) suggested that in order to understand PCK, it is important to examine how it is used in the classroom.

Summary. The studies on the curricular knowledge of NHTS highlight the influence of the classroom on the curricular knowledge. That is, NHTS used curricula to plan instruction, and not as guides to enhance the learning of their students. In taking this position towards curricular materials, these studies illustrate that NHTS are not maximizing the potential of these materials.

The studies on teacher knowledge, with the exception of Shugart and Hounshell (1995), provide descriptions that offer important insights into the different views of teacher knowledge. They also demonstrate that NHTS tend have different manifestations of specific knowledge bases. Understanding how different forms of the same knowledge base are cultivated among NHTS continues to be an area worth exploration.

The group of studies on teacher knowledge also assumes a connection of knowledge to practice. Unfortunately, the connection of knowledge and practice is not straightforward. Given the complexity of teacher knowledge and the complexity of teacher practice, there is more research to conduct in this area. One place to begin is in the development of theories or models in this area that connect knowledge and practice. Theories and models would allow researchers in this area to strategically and collectively contribute knowledge to this pressing problem.

Impact of Professional Learning on Teacher Knowledge

The studies in this subarea sought to understand the impact of professional learning opportunities on teacher knowledge. The outcomes of these opportunities included measures of practice and teacher learning. Several of these studies involved a type of mentorship program, where a NHTS was assigned to work with a more experienced colleague. Professional development programs that involved workshop-type activities, or the introduction of curriculum meant to educate the teacher were other types of professional learning experiences.

The research on mentorship programs varied significantly. In one study, the interactions between the mentor and NHTS were limited to a workshop setting. Williams et al. (2012) designed a workshop in New Zealand for secondary teachers in which teams worked together to develop a detailed description of a content area and relevant pedagogical concerns (content representations or CoRes). Two teams included an expert classroom teacher, a scientist or technologist, two NHTS, and two experienced science education researchers. After participating in this unique team, NHTS were observed teaching and then interviewed. NHTS reported improved knowledge and confidence. Additionally, NHTS’ practices were focused on authentic examples, conceptual thinking and big ideas indicating improved PCK.

Other programs with NHTS required mentors and mentees to have multiple interactions outside of a formal workshop setting. In one study, 13 newly hired Canadian elementary teachers were paired with more experienced teachers in the same school district (Gustafson, Guilbert, & MacDonald, 2002). Pairs met during a half-day university-based seminar and were encouraged to meet again later in the experienced teacher’s classroom. Analysis of interviews with these elementary NHTS showed that this limited experience led to an increase in general pedagogical knowledge.

The study conducted by Simonsen, Luebeck and Bice (2009) also included interactions of mentor and mentee pairs outside of formal workshop setting. However, unlike the previous study, these interactions took place over the course of a year in an online environment with a facilitator. Over 1,600 online messages between newly hired secondary mathematics or science teachers and their mentors were coded into categories of knowledge types including PCK, subject matter knowledge, and pedagogical knowledge. Researchers found that messages requesting information focused on pedagogical knowledge, while messages between mentors and mentees focused on PCK. Co-construction messages were more common among mentees who stayed in the mentoring program longer.

The remaining studies in the area of professional learning did not include a mentoring component. Justi and van Driel (2005; 2006) reported on the results of a professional development program developed to strengthen secondary Dutch NHTS understanding of models and modeling. Participants in this professional development received instruction over six weeks regarding models and modeling. The NHTS then designed an action research project related to modeling to conduct in their own classrooms. Questionnaires, interviews, program artifacts, and transcripts from the program were data sources. The design of the program and the analysis of the data were guided by a model with four components that interacted in non-linear ways. The components were: knowledge, beliefs, attitudes; external source of information or stimulus; professional experimentation; and salient outcomes. A case study (Justi & van Driel, 2005) and an analysis of diagrams created by NHTS revealed that they improved their knowledge as a result of the program.

In another study related to the impact of professional development programs on curricular knowledge, Lynch, Pyke and Jansen (2003) designed a program that specifically increased NHTS' knowledge of the principles in the Project 2061 curriculum (American Association for the Advancement of Science [AAAS], 1993). In this program, 15 secondary science and mathematics teachers and one museum education master's student selected an online dataset that their students could use in class. They then designed a framework based on the database and Project 2061 principles. Frameworks were analyzed using a rubric that looked for the alignment of state curriculum to Project 2061 principles. Researchers found that teachers were able to find databases and construct frameworks that aligned with the standards and principles emphasized in the program. A representative case study of one participating teacher described the successful implementation of this curriculum framework in the classroom, further supporting the effectiveness of the professional development program.

Another strategy for improving the knowledge of NHTS is an educative curriculum. In this type of curriculum, information is embedded in the curriculum to help the teacher learn content knowledge, pedagogical knowledge and PCK. Being situated in classroom practice, some argue, make it an ideal medium for promoting teacher learning. In Schneider and Krajcik (2002), middle teachers attended a two-week workshop introducing them to such a curriculum. Data was collected for three participating teachers (two of which were NHTS) in the form of videotaped observations (a total of 25, 15, and 5 hours for each teacher) and multiple interviews. Analysis sought to understand the teachers' knowledge, use of educative curriculum, and their connection. Schneider and Krajcik (2002) suggested that the educative features of the curriculum were beneficial for teacher knowledge, especially related to PCK.

Finally, Adams and Krockover (1997) investigated the connection between an initial certification program for secondary teachers and NHTS knowledge. This was done by conducting multiple interviews, observing one lesson, collecting artifacts, and viewing videotaped classroom interactions with four NHTS. These data sources were analyzed for evidence related to pedagogical knowledge and PCK. In general, NHTS attributed their teacher education program as the source of their knowledge about classroom discipline, organization and instructional strategies. Other sources such as high school and other university coursework were also cited as influential sources of their knowledge for teaching.

Summar. These studies emphasize the importance of different professional learning opportunities for NHTS. Professional learning for NHTS can include mentoring, professional development programs, workshops, or curriculum. However, these learning opportunities do not result in a straightforward process of transmitting knowledge. Teacher knowledge in these examples was constructed with colleagues, many who were more experienced than the NHTS, and in settings that promoted purposeful discourse. These programs were also designed with an explicit purpose (e.g., use a model, or curriculum) or outcome (e.g., support NHTS).

Additional studies in this area should explore how teachers construct their knowledge in the different environments of professional learning. This orientation may explore how colleagues specifically support the development of knowledge among NHTS.

Influence of Teaching Experience on Teacher Knowledge

The third subarea of studies on teacher knowledge examined the influence of teaching experience on teacher knowledge. While it is commonly believed that experience is essential in building teacher knowledge, the research shows that the influence of experience is complex.

Friedrichsen et al. (2009) examined the knowledge of 13 NHTS who had not participated in a traditional teacher preparation. Some of the participants had previous teaching experience and some had no experience in the classroom. The secondary science teachers were asked to design a lesson plan on a specific topic in a controlled situation (e.g., same amount of time, materials, topic) and they were interviewed regarding their lesson plan, and their PCK and subject matter knowledge. Overall, their results suggested that teachers with classroom experience had more developed pedagogical knowledge, while teachers with and without teaching experience had similar PCK.

Smith (2007) followed UK primary teachers from their initial certification program to their first years in the classroom. He was interested in understanding how teacher knowledge developed over time, and how identify interacted with knowledge development. Over a three-year period, assessments, interviews, classroom artifacts were collected from 21 teachers. From this group, representative cases were developed illustrating trends in the data. The analyzed data and cases revealed that these primary teachers developed and represented their content knowledge and PCK in different ways. It also revealed that the identity of the teachers was influenced by their current teaching experience, and that their identity influenced how they constructed their content knowledge.

In a yearlong study (Lee et al. 2007) documented the development of PCK among 24 NHTS who were participating in one of four induction programs. Teachers were interviewed at the beginning and end of the school year, and were observed throughout the year. Researchers assessed the level of PCK demonstrated in interviews using a rubric. At the end of one year, there was no difference in the representation of PCK between the different induction groups. However, all of the teachers demonstrated more developed knowledge of student learning.

Studies that extended beyond the first year of teaching provide even more insights into teacher knowledge development. Findlay and Bryce (2012), for instance, followed six Scottish physics teachers over their first four and a half years as teachers. Data sources included four semi-structured interviews distributed over this time-span. Researchers coded the interviews in terms of: curricular knowledge, subject matter knowledge, general pedagogical knowledge, contextual knowledge, values, and learners' reflections. The analyzed data showed that these teachers were initially focused on the adequacy of their subject matter knowledge and their ability to present the information to students. Over time, they began to shift their focus to the learning of their students. The researchers suggested that over time subject matter knowledge connects to general pedagogical knowledge and contextual knowledge.

Arzi and White (2008) applied a similar methodology, but over a longer time period and with a larger sample. Data was gathered from 22 secondary Australian teachers over a period of 17 years. The primary data were interviews related to specific content areas. Analysis of the data focused on how these associations and meanings changed over time. Arzi and White (2008) concluded that the content knowledge of these teachers changed over time, with some topics weakening and others strengthening. The strongest determinant of teacher content knowledge over 17 years was the required curriculum, with additional knowledge restructuring coming from experience with students. Content knowledge growth was constrained when teachers did not teach the same content over time, and they taught outside of their specialized area of preparation.

Mulholland and Wallace (2005) followed an Australian elementary teacher, Katie, over 10 years. During this time, they collected interviews, participant observation field notes, and journals. Narratives related to phases in Katie's development were constructed from the collected data and compared to one another in order to depict the development of her PCK. In the analysis, the researchers examined science subject knowledge, general teaching knowledge and interactive knowledge. Initially, her subject matter knowledge was strong, but by the end of the ten years, Katie's subject matter knowledge had grown minimally. However, her interactive knowledge and general teaching knowledge had grown considerably.

Summary. These studies illustrate that teacher knowledge changes over time. Collectively, these studies suggest that teaching experience most strongly influences general pedagogical knowledge, and that there may be some growth in content knowledge and PCK with teaching experience. The factors that contribute to the change in a teacher's knowledge range from the curriculum they use to the students they interact with regularly in the classroom.

Future research in this area would benefit from additional longitudinal studies that explore different factors that contribute or constrain teacher knowledge development. These studies can be initiated in an initial certification program, or in the first year of teaching. Beneficial research would also examine how a similar or different teaching assignment contributes to knowledge development. For instance, examinations of teacher knowledge during out-of-field teaching, or teacher knowledge as one teaches the same subject over many years would be beneficial to the community.

Area Summary

The teacher standards guiding this review reinforce the importance of teacher knowledge, and they require that teachers have well-developed knowledge. When school personnel monitor and assess the knowledge of NHTS, they will be looking for well-developed knowledge. To guide the efforts of school personnel, it will be important to understand the composition and construction of teacher knowledge. While this area has a significant amount of research, teacher knowledge is still undefined in the educational community. This area review reinforces the importance of knowledge, but it also shows the complexity of teacher knowledge. Therefore, further work, both in research and theory, is needed to clarify teacher knowledge.

From this review, there are conclusions and research suggestions that can be made about NHTS knowledge. One of the most important findings to emerge from this review pertains to differentiated development of knowledge among NHTS. New science teachers have different forms of knowledge, and these are impacted differently by various factors. For instance, NHTS seem to benefit in building their PCK and their pedagogical knowledge as they work in the classroom and with their peers. Sometimes, NHTS built their knowledge to a greater degree than that of their experienced peers. Future research in this area should clarify how different forms of teacher knowledge develop and what factors contribute to the strengthening and sustaining of teacher knowledge.

Another finding pertains to the population of study. The majority of studies in this review were on secondary teachers, and not elementary teachers. While both are charged with teaching science, the very nature of how elementary teachers construct and implement their knowledge is worth exploring in future studies. For instance, the subject matter of knowledge of elementary teachers may be influenced to a greater degree by curriculum resources, as opposed to peer-collaboration. Future research in this area should certainly explore the knowledge construction of both elementary and secondary NHTS, but there is need to explore the knowledge of elementary teachers. Findings from these studies could guide how newly hired elementary and secondary teachers are supported to build their knowledge.

Area: Learners and Learning

Research on learners and learning focuses on understanding how students learn and how educators can promote learner development. Most articles that were reviewed for this section utilized either case studies or teacher action research to qualitatively explore learner development, individual learning differences, and the process of learning. For instance, Meyer (2004) conducted a comparative case study of six teachers--two preservice teachers, two first-year teachers, and two veteran teachers. The collected data included semi-structured interviews, classroom observations, and classroom documents. The cases revealed that the more experienced teachers were more robust in their understanding and use of student prior knowledge, while the

NHTS held insufficient conceptions of students' prior knowledge. As a result, NHTS could not effectively implement learner-centered instruction.

Similarly, Mitchener and Jackson (2004) used a case study to examine the relationship between action research and practice of a middle-level NHTS. This NHTS conducted an action research investigation of her pedagogy, which was used as a source of data for the study. Data included action research proposals, updates, and reports; discussion notes and tape recorded meetings; field observation notes; and formal teaching evaluations. The analysis of data revealed that a richer dialogue between her and her students occurred during class discussions over the course of her action research projects. Ultimately, an action research project helped the teacher modify her practice and improve student learning.

Similarly, Kang (2007) concluded an analysis of 14 elementary NHTS action research plans that included teacher reports, lesson plans, student artifacts, and video recorded teaching episodes. An analysis of this data revealed the teachers utilized students' ideas in different ways. From this study, it was suggested that teachers, especially those new to the field, could benefit from support to improve their awareness and instructional use of students' cognitive resources.

Other research on NHTS has shown similar advances in their development of practices attuned to student thoughts and ideas. While questioning is an important component a student's science education experience, student questions are not always a welcome part of classroom discourse. In a case study using field notes, tape recorded classroom discourse and semi-structured teacher interviews, Rop (2002) documented a fifth-year chemistry teacher using student questions as a means to diagnose student attitudes and abilities. Throughout the study, the teacher was observed to enlist various response strategies to student inquiry questions, so that he was ultimately able to maintain control over the flow of daily lessons.

In a similar case study that used semi-structured personal interviews, semi-structured focus group discussions, field notes, and classroom artifacts, Peters (2010) described how a first-year middle school teacher implemented a student-centered classroom with students who had little or experience with this type of set-up. To be successful, she constantly monitored student behavior and attitude, and adjusted where necessary--including scaffolding student expectations and performances.

In interviews with eleven NHTS in their third year of teaching, Demetriou and Wilson (2009) identified several themes surrounding strategies to survive and improve early in a teaching career. In the interviews, many of the suggestions related to building positive relationships with students, communicating effectively with students, and reflecting back on one's practice, especially to consider relationships and communication. This research points to the capacity of NHTS to develop their practice in terms of understanding student learning. Such capacity can likely be improved for science teachers at all career stages.

Area Summary

Without a strong knowledge base of student learning or learners in science, NHTS will not be able to attain the standards in this area. Unfortunately, there were relatively few articles in this area. One reason for such a small number is the general approach to learners and learning, and not a focus on learners and learning within science education. In addition, a knowledge of learners—student interests, factors that motivate them, potential misconceptions—can be subsumed under PCK. At times, it was difficult to separate studies about learners from studies related to PCK. Additionally, many studies of learners and learning applied to science education do not focus on NHTS. Rather, examinations of teachers' conceptions of student learning and the process of learner development focused predominantly on pre-service or experienced teachers.

Among the studies that are presented, it is evident that a focus on learners and learning (e.g., action research) can help NHTS understand their students and the learning of their students. It is also evident that NHTS have different motivations for understanding their students. These findings reinforce that focusing on learners and learning can be prompted or come from the teacher. What is not known, however, is how NHTS build their capacity to understand learners and learning, and how they can be supported in their preservice and induction programs to build an understanding of learners and learning.

This is an area that is ripe for research, and this research must focus on the complex interaction of NHTS and their students, and how to support NHTS to build their knowledge in this area.

Area: Professional Practice/Learning Environments

Studies in this area are focused on the instructional practice of NHTS, or on the creation of science learning environments by NHTS. As will become apparent, there are different ways to examine teacher practice and there are different approaches to understanding factors that relate to teacher practice or learning environments. In reviewing articles in this area, there were four general trends in the research. In some of the studies, just descriptions were offered by the researchers about the professional practice of NHTS. These studies described the instruction or learning environments of NHTS. In other studies, researchers explored how NHTS developed their practices over time. These studies examined how practices changed over some period of time in the classroom. The third group of studies examined how internal and external factors impacted the professional practice of NHTS. These factors ranged from the beliefs of a teacher, to the context in which a school was located. In the final group of studies, researchers explored how educational interventions changed teacher practice or the enacted learning environments.

Depictions of Professional Practice/Learning Environments

Studies in this section vary significantly. Some studies describe the use of novel professional practices, while other studies describe the enactment of valued practices among NHTS. Ultimately, by understanding how NHTS teach, ways to support teachers can be individually and appropriately tailored. That is, some instructional areas may response well to support and influence the formation of other practices. Other areas may not respond as readily and may need to associate with other instructional practices in order to be utilized in the classroom.

Teaching science is important among elementary teachers. However, it is not common that elementary teachers have a science major or strong support for the teaching of science. Studies which describe the science instruction of elementary teachers provide insights into supporting their science instruction endeavors. Avraamidou and Zembal-Saul (2010; 2005) have published two studies that describe the instruction of a well-started elementary teacher.

In the 2010 study, Avraamidou and Zembal-Saul explored how inquiry science was enacted in the elementary classroom. Their qualitative case study documented the instruction and PCK of two first-year elementary teachers. Both teachers graduated from the same teacher education program. Interviews, observations, and classroom artifacts were collected and analyzed in order to describe their instruction. From the analysis of the data, they found that their teachers did not achieve the competency or sophistication of other experienced teachers. However, their instruction was guided by an understanding of inquiry science, which came from their preservice program or the materials they were using class.

An earlier case study by Avraamidou and Zembal-Saul (2005) examined the nature of a first-year teacher’s practices. They were specifically interested in how a NHTS would give priority to evidence in her classroom and what knowledge supported these instructional practices. The analyzed interviews, observations, and classroom artifacts revealed that the teachers were able to engage in their students in instructional opportunities that allowed the students to give priority to evidence. Furthermore, they concluded that her understanding of this form of instruction was congruent with her knowledge in this area. This congruency was attributed to her preservice program, which allowed her to practice this type of instruction.

Among secondary NHTS, the results are not so positive in terms of instruction. In a study of a 98 beginning secondary science, 17 beginning secondary mathematics, and 1 beginning mathematics and science teachers, Simmons et al. (1999) sought to document the instructional practices and beliefs of teachers in their first three years. Videos of three days of instruction, a teaching journal, and interviews with the teachers were analyzed in order to understand their beliefs and practices. The analysis of data revealed that while teachers professed student-centered beliefs, they behaved in teacher-centered ways. It addition, the analyzed data also revealed that teachers wobbled between student-centered and teacher-centered positions, with some congruence between these orientations in their third year of teaching.

Likewise, Demir and Abell (2010) interviewed and observed four NHTS to understand their views and implementation of inquiry. All of these secondary teachers came from the same initial teacher certification program. Interviews, videotaped lessons, and classroom artifacts were collected from the teachers. The analysis of the collected data revealed that the NHTS held incomplete views of inquiry, and only one of the NHTS was able to implement some form of inquiry into her classroom. They attributed the lack of inquiry implementation and knowledge to the initial teacher certification program.

Finally, in a study of practice, the incorporation of technology into the classrooms of beginning science teachers was investigated. In one study, Dawson (2008) conducted a survey and interviews of NHTS teachers in Australia regarding their use of Information Communication Technology (ICT) resources. The 33 secondary science teachers were in their first, second, or third year of teaching. The analyzed data revealed that the teachers felt confident and valued technological resources used in their teaching. They also believed that they had the necessary skills to use ICT. However, in most cases their ICT use was limited to lesson preparation (word processing), personal communication (email), and conducting research on the Internet. Teachers did not use ICT with their students in the science classroom. Specifically, they reported little to no use of data probes, e-journals / portfolios, discussion groups, or virtual excursions.

Summary. These studies reveal the uneven nature in which science instruction is implemented in classrooms in the first years of teaching. For the secondary teachers, even from well-regarded preservice programs, their instructional practices were varied. From the elementary sample, even the well-started beginning struggled to enact valued instructional approaches. These studies are a just a first glimpse into the classrooms of NHTS and they reinforce the need for more studies in this area.

Learning to Teach

The following studies extend beyond descriptions of professional practice and attempt to provide insights into the process of learning to teach science. All of these studies follow teachers over a period of time, and they try to understand some aspect of how teachers build their instructional practices.

In the only study pertaining to elementary teachers, Forbes and Davis (2010) followed four elementary teachers over their first years of teaching. They were interested in how beginning teachers engage their students in asking and answering scientifically oriented questions, and how their beliefs support this type of instruction. Interviews, online journals, and logs of their instruction were collected in order to document their practices and beliefs over three years. The analyzed data resulted in individual cases. From these cases, it was found that the teachers held unique ideas about the use of driving questions and investigations. It was also found that their practices evolved differently over time as they worked with students in classrooms. Overall, the beliefs of the teachers, as well as the context in which they worked influenced their use of driving questions and investigation questions.

The studies about secondary science teachers offer different perspectives on learning to teach, although there are some common themes among them. In an early study, Brickhouse and Bodner (1992) followed McGee over a period of seven months in order to understand how he moved towards the instructional environment he envisioned. In order to capture his practices and beliefs, observations, interviews, and classroom artifacts were collected. The analysis of data revealed that McGee experienced conflicting beliefs about what he envisioned and what was possible. The constraints emerged from within the school, and within the classroom among the students. In resolving these constraints, he learned about how to compromise his vision in order to meet the demands of the students and the school.

A few years later, Loughran (1994) interviewed NHTS in Australia in order to understand their pedagogical development. The interviews were conducted with 14 second-year secondary science teachers, and they were analyzed in order to understand salient views about teaching science. From the analyzed interviews, the NHTS revealed several constraints that included not enough time to contemplate the topic of instruction or master the content, increased confidence in the second year in one’s own ability to teach the topic, and the importance of a supportive community. Several of these teachers indicated that their current experiences were a result of what they had learned in their preservice programs. These results led Loughran (1994) to suggest that preservice education was repressed, and not discarded as suggested by other researchers.

Fletcher and Luft (2010) followed five secondary science teachers from their initial certification program through their first year of teaching. Interviews and classroom artifacts were analyzed in order to understand how field experiences influenced their beliefs about reform-based practice. The analyzed data revealed that teaching beliefs of the teachers moved towards more traditional orientations, while the learning beliefs of teachers maintained a contemporary orientation. The field experiences did impact the beliefs about teaching and learning in different ways. This study revealed the complexity of beliefs and field experiences.

Roehrig and Luft (2004) followed 14 NHTS teachers over the course of a year, in order to understand how they implemented inquiry in their classrooms. The interview and observational data revealed that different factors impacted teachers differently in their use of inquiry in the classroom. Their beliefs, knowledge of instructional practices, prior experience with inquiry, knowledge of the nature of science, along with perceptions of the students all seemed to impact the instruction they enacted in the classroom. For instance, in this study inquiry teachers held student-centered beliefs, a contemporary view of the nature of science, and strong content knowledge (a major in their content area). None of these factors alone (e.g., beliefs, nature of science, content knowledge) were sufficient to support inquiry instruction, as even teachers with strong content knowledge were constrained by their concerns about student ability, motivation, and classroom management.

Summary. From these studies it is clear that NHTS are building their instructional knowledge as they are learning to teach. They are learning about their own instruction, about their students, and about the school context. Yet while they are learning how to teach science, NHTS are drawing upon and confronting the knowledge they gained in their initial certification program while navigating students, content, and context. In addition, these studies also suggest that some attributes from an initial certification program continue to persist into the first years of teaching. Yet, the school context can have a strong influence over the instruction of a NHTS. Clearly, the learning of NHTS is a process of synthesis and vacillation, which draws upon prior knowledge and experiences.

There is a need for additional studies that describe the learning of NHTS within new environments and in consideration of their preservice coursework. These studies will depict how NHTS develop and what practices or cognitive attributes should be supported or challenged as they engage in their first years of teaching. Comparing NHTS from different preservice programs, in different school environments, and in different contexts will provide additional information about the development of the instructional practices of NHTS.

Factors Related to the Instruction of NHTS

This section shares research that explores how NHTS are supported to enact their professional practice or construct learning environments. The factors explored range from internal factors, which included beliefs or emotions, to factors that are cultivated externally, which includes school context, curriculum or professional learning opportunities. Teacher knowledge was addressed earlier in this paper, and as a result is not covered in this section.

Internal factors-cognitive areas-beliefs. Research in this area addresses the beliefs, self-efficacy, or emotions of teachers. Among these areas, research into the self-efficacy of teachers is most prominent and elementary teachers are often the study population. One of the earliest studies pertaining to NHTS was conducted by Ginns and Waters (1999). In this study, they assessed the self-efficacy and instruction of three beginning Australian elementary teachers at the conclusion of their initial certification program and at the conclusion of their first year of teaching. A self-efficacy instrument, observations, videotapes, field notes, and interviews were collected in order to the experiences of the teachers as they engaged in teaching for the first time. From the data and a multiple methods analysis, they concluded that self-efficacy beliefs alone do not appear to account for a teacher's decision to implement inquiry instruction. The teachers were influenced by the feedback of students, their excitement for hands-on science and their own positive experiences.

In trying to understand the construction of self-efficacy, Mulholland and Wallace (2001) followed an Australian elementary teacher from her teacher preparation program to her first year in the classroom. Interviews, observations, and journals were used to document the self-efficacy of Katie. From the data, a case study was constructed that illustrated that mastery experiences, verbal persuasion, and other forms of social persuasion impacted the efficacy of Katie. Vicarious experience, and affective and physiological states did not have an impact on Katie, which was counter to the published findings of other researchers. Mulholland and Wallace (2001) ultimately concluded that NHTS may have experiences that have positive and negative effects on self-efficacy.

Anderson et al. (2004) implemented a multiple methods study that examined the self-efficacy and the instructional environment of Danish first year elementary teachers. They used a self-efficacy instruments, observations, and interviews to understand how the self-efficacy beliefs of the teachers interacted with their teaching environments. In their study, they initially sampled 39 teachers to understand their trends in self-efficacy in their first year in the classroom. Three teachers were ultimately selected that represented some of the trends of the group. These teachers participated in additional observations and interviews. From the analyzed data, it was suggested that there was some relationship between teaching environment (e.g., mentor, administration, other teachers) and self-efficacy. Anderson et al., (2004) ultimately suggested that a positive teaching environment may be linked to high self-efficacy, which may impact instruction.

In addition to self-efficacy belief studies, there are studies that explore different types of beliefs of teachers. Crawley and Salyer (1995) examined the beliefs of four teachers (three who were NHTS) who were beginning to implement a new integrated science curriculum. Questionnaires, interviews, and journals were collected and analyzed in order to understand the beliefs of the teachers. The analyzed data revealed that teachers expressed beliefs that the new curriculum would likely be beneficial for student learning, but there would be challenges in implementing the curriculum. Specifically, the integrated curriculum would require teachers to enhance their knowledge of the curriculum in other grades and in order increase the coordination across grades.

Another study about new teachers' beliefs was conducted by Marbach-Ad and McGinnis (2007). They conducted an attitudes and beliefs survey of 31 beginning mathematics and science teachers after they graduated from their teacher preparation program, and after 2-3 years of full time teaching. They also selected 6 teachers to interview in order to understand the quantitative data. The analyzed data revealed that graduates of a reformed-based program maintained their reform-based beliefs and perspectives about the workplace. The effective design and implementation of the reformed-based program was a major conclusion of this study.

Monteiro, Carrillo, and Aguaded (2010) follow a first year primary school teacher in Portugal in order to understand how his 'scripts,' and beliefs and actions. Their study examined the unique relationship of practice with beliefs and knowledge, and documented this relationship through ‘scripts.’ By analyzing selected instructional events, Monterio et al., (2010) showed how different beliefs and knowledge guide instruction in the classroom. They ultimately suggested that teacher scripts can help teachers better understand their practice, as well as the relationship between beliefs, knowledge and practice.

Internal factors-cognitive areas- emotions. Two studies explored the connection of emotion to teaching. For instance, Ritchie, Tobin, Hudson, Roth and Mergard (2011) and Roth, Ritchie, Hudson, and Mergard (2011) shared the emotional experiences of Vicki -an Australian NHTS- as she taught different science lessons. Video-recorded lessons, interviews and personal artifacts revealed how emotions were used during her classroom instruction. Through the use of humor, laughter, and positive comments, she was able able to create purposeful conversations between herself and the students. For her, humor helped to create collegiality and community in the classroom.

Dreon and McDonald (2012) were interested in how different affective factors impacted a teacher’s ability to conduct inquiry. In their study, the teachers were interviewed and their weblog posting were followed in order to understand their emotional engagement with their teaching. The analyzed data revealed how two secondary teachers felt unprepared to teach science through inquiry, and experienced an emotional response when planning for and implementing inquiry. These responses ultimately constrained their use of inquiry.

External factors - school context. School context often includes colleagues, administrators, and programs that are configured to support NHTS. These studies often connect initial teacher preparation to the first years of teaching, and look at the influence of the school on the instruction of the NHTS. In a study of K-8 teachers, McGinnis, Parker, and Graeber (2004) studied five first and second year teachers to understand how they were inducted into their school environment. All of the teachers were prepared to be mathematics or science specialists. Interviews and observations revealed that the perceptions the teachers held about their school influenced their instruction. Teachers who perceived support for their reform-based instructional methods were able to enact these methods. Teachers who did not feel supported developed different strategies to cope with the constraining school culture, which ranged from leaving the school to implementing some level of reform-based instruction.

Parker et al. (2010) also followed three secondary teachers from their teacher education program into their first years into the classroom. The teachers in their program were supported to learn how to enact a conceptual change approach towards teaching. While all of the teachers demonstrated the ability to enact conceptual change during their preservice program, once they started their teaching careers—the context in which they worked stifled their use of conceptual change in their instruction. Knowing the struggles of NHTS, Parker et al., (2010) suggested that the preservice program could have better supported the teachers in their learning of conceptual change.

Summary. The studies reviewed in this section illustrate the different factors that support the professional practice of NHTS. In the area of beliefs, examinations of self-efficacy are prevalent among elementary education students and international researchers. In the area of beliefs, there are general investigations among elementary and secondary teachers. As research progresses in the area of beliefs and practice, it will be important to continue understanding the direct link between beliefs and teacher practices.

The emerging area of emotions adds a dimension to understanding practice. Studies in this area offer insights into a side of teaching that is underexplored. For NHTS the added emotions of becoming a new teacher, learning how to implement instruction, and learning about one's school, certainly impact decisions in the first years of teaching. This is an important and underexplored area.

There is no doubt that context is important as NHTS are socialized into their schools and the community of science education. These studies emphasize the important role that context plays in the instruction of NHTS. Understanding exactly what contextual factors impact the practices NHTS will be important in the upcoming years. For instance, it would be worth examining how administrators create supportive environments and the varying degree in which these environments can impact the practice of a NHTS.

Interventions that Impact Teacher Practice

The area of interventions has a significant number of studies. These studies focus on the implementation of professional development programs, as well as the adoption of curriculum to assist teachers in their classroom instruction. This discussion will begin with studies that link initial certification programs to the first years of teaching. It will then progress to a discussion of induction programs and conclude with the research that following NHTS in professional development programs.

The influence of teacher preparation. McDevitt, Gardner, Shaklee, and Berthholf (1999) conducted one of the earlier studies that linked initial preparation to the first years of teaching. In their study, they surveyed student teachers and newly hired elementary teachers who came from a reform-based initial certification program and a traditional initial certification program. The survey data of the two groups were compared, although there was no special attention to understanding the differences between student teachers and newly hired teachers. From the survey data, McDevitt et al. (1999) noted the limitations of the study and concluded that the teachers from the reform-based program were more likely to engage in instruction that considered students' misconceptions, connected the instruction to students' live, emphasized problem solved, and encouraged students to make observations, do experiments, and draw conclusions.

Brown and Melear (2006) conducted a study to understand how an inquiry course in an initial certification program contributed to the instruction of NHTS. They used interviews and observations to measure the beliefs and practices of the 8 secondary science teachers, of which 5 were NHTS. The analyzed data revealed the teachers with more experience did not achieve a student-centered orientation, and several teachers had inconsistencies between their beliefs and practices. That is, teachers enacted instruction that was inconsistent with their beliefs. Ultimately, the inquiry course during a preservice program did not impact the instruction of NHTS, but it may have contributed to teachers' conception of inquiry.

Roehrig and Luft (2006) followed secondary science teachers from their preservice program into their first years in the classroom. Observations and interviews were conducted with the teachers frequently. Teacher cases were created from the data, then compared to each other in order to understand the trends among the teachers. The cross case analysis revealed that NHTS were more likely to enact inquiry environments and hold views supporting inquiry if they had a year of science methods (2 methods courses), a year of student teaching (4 hours a day), and if they participated a science specific induction program in their first year. These experiences reinforced inquiry instruction, and provided ample opportunities for the teachers to learn and practice inquiry instruction.

Supporting the professional practice of NHTS. Videotaping has been used in classrooms to have teachers evaluate their practice. In a study by Shey and Baird (1993), the potential impact of watching one's video of teaching during the first year of teaching was explored. A group of 20 first year Taiwanese elementary educators were divided into two groups. One group of 10 was assigned to meet with a university supervisor three times to discuss their teaching. The other group of 10 met with the university supervisor and received feedback on their videotapes. Over the six months, the teachers who watched videos with their supervisors significantly improved their attitudes towards teaching and they improved specific teaching behaviors, such as wait time, higher level questions, and praise for students.

Forbes (2004) piloted a model of peer mentoring that connected NHTS from different schools. In his pilot program, three teachers worked with each other over the course of a year. Interviews with the teachers, and the journals of the teachers, were used as data sources. These sources of data were analyzed to understand the value of the program. From these data, it was concluded that the peer mentoring program had an effect on a small group of teachers. These teachers gained insights into curriculum structure, managing student behavior, and utilizing new instructional approaches.

Koch and Appleton (2007) developed a program that supported two early career teachers in their schools in Australia. In their study, they worked closed with two elementary teachers in order to support their use of constructivist instructional approaches. Through a program that involved co-teaching, the NHTS were able to probe student thinking and engage students in questioning. The teachers valued this type of support, and it did encourage science instruction in their classrooms.

Induction and professional development programs. In order to understand how beginning teachers changed in terms of their instruction and beliefs, Luft (2001) enrolled 14 beginning and experienced teachers in a professional development program that supported the use of ‘science as inquiry’ (NRC, 1996) in the classroom. As both groups of teachers participated in the program, their beliefs and classroom practices were monitored monthly. At the conclusion of the year-long program, Luft (2001) found that the NHTS more readily changed their practices than their beliefs, while experienced teachers more readily changed their beliefs than their practices. It was suggested that the NHTS had beliefs and practices that were still changing, with the beliefs driving practice.

Years later, Luft modified this professional development program to specifically meet the instructional needs of NHTS. With a pool of over 100 NHTS, four different induction programs were created to support the NHTS. The programs consisted of two forms of science specific mentoring (electronic and face to face) and two forms of general mentoring (school district organized and support for teachers without credentials). Observations and interviews were collected as the beginning teachers worked in their classrooms and attended their different induction programs over a two-year period. After the first year, Luft (2009) reported that the NHTS in the science induction programs enacted more ‘science as inquiry’, improved their PCK, and developed student centered beliefs. These findings suggested the importance of science-specific induction programs. After the secondary year, Luft et al. (2011) found that the NHTS were impacted more by their school or science community, that their instructional practices moved more towards the norm of their school community. From these studies, the community in which the teacher worked had a greater impact on the instruction of the teacher than did the induction program, and teachers readily changed their PCK as they worked in classrooms.

Two additional studies in this area involve NHTS. Roehrig, Kruse and Kern (2007), worked with 27 chemistry teachers for a year as they implemented a new curriculum. More than half of the teachers were beginning teachers, while the remainder were experienced teachers.

Interview and observational data revealed that the beliefs held by the teachers influenced their enactment of the curriculum. In addition, a supportive context was a factor in the implementation of the curriculum.

McGinnis and Simmons (1999) enacted a professional development program that supported teachers in their use of controversial issues in their classroom. Three of the five participants were NHTS (first and second year, and elementary and secondary).This qualitative study drew upon surveys and observations of the teachers in the professional development program. The analyzed data revealed that the teachers reported being influenced by their community in terms of their enacting various forms of instruction, with new teachers feeling professionally vulnerable. Also, teachers who lived outside of the community in which they worked felt challenged in implementing controversial topics.

In a district wide study, Borman, Gamoran, and Bowdon (2008) used standardized tests of 4^{th} grade students to analyze the results of a professional development program that supported teachers to use inquiry. This study involved eighty schools in the Los Angeles Unified School District, with approximately half of the schools participating in the program and half not participating in the program. Overall, the professional development program had negative effects on student test scores for veteran teachers, but positive effects for NHTS in their first three years of teaching. This research suggests that NHTS may be more flexible in their conceptualization of science and more amenable to changes in their educational approach.

Summary. The studies in this section explore how different interventions and programs influenced or changed the instructional practices of NHTS. While one course in an initial certification program may be all the opportunity a teacher has to learn about instruction, from these studies it is clear that just one course is not enough. These studies suggest that a sustained focus on practice during initial certification, and potentially through the first years of teaching can impact the practice of a NHTS.

Promising approaches to support NHTS in building their knowledge consist of the use of videos, ongoing feedback, and creating communities of learners. These approaches help NHTS build their practice through reflection, dialogue, and analysis. In addition, professional development programs that support science instruction also appear to assist NHTS. There is some evidence that NHTS may even benefit more from professional development opportunities than their experienced colleagues.

Future research in this area should strive to understand how to maximize the learning of teachers. For instance, programs that specifically target a small aspect of practice may better assist NHTS. There is also a need to explore how web-based programs or technology can be used to help sustain and strengthen the practice of teachers. Videos of practice, online meetings, and even blogs offer ways for teachers to reflect upon and refine their instructional practice.

Area Summary

A significant amount of research has occurred in this area, and this work highlights the importance of examining and supporting the professional practice of NHTS. The studies that look at the professional practice of new teachers provide important information about how new teachers enact their professional knowledge, and what factors impact their professional practice. It is these studies that begin to give specific guidance to those who do work with NHTS.

For those who work with and study NHTS, there are conclusions that can be made and there are directions for further study. For instance, an important conclusion from this work pertains to the complexity of impacting teacher practice. The professional practice of teachers is complex and it can be guided by several different factors. For instance, there is some evidence that the prior experience of a teacher can influence how he or she enacts different forms of science instruction, or there is some evidence that the beliefs of a NHTS influence instruction.

Another conclusion in this area pertains to the importance of the context in which NHTS work. These contexts can be supportive environments that promote the practices that are valued, or they can constrain the emerging practices. Along with the context in which a teacher works, collaborations are also important to the NHTS. It is evident that when teachers work with one another or with other educational specialists, there is improvement in their instructional practice. Collaborations can reside in, for instance, mentoring relationships, collegial discussions, professional development programs, or small professional communities.

In addition, there is evidence that when NHTS are supported during their initial years, they do engage in practices that are valued by the community. Supporting teachers in their initial years strengthens important practices and skills, and potentially establishes the capacity to learn new practices.

While there are conclusions that can be offered, there is a need for additional research in this area. Some of the more important questions worth investigation include: Are there core or essential instructional practices that can be learned during initial certification that are more conducive to creating sound learning environments? If so, do these practices transfer between content areas?; Are the different amounts of collaboration that are supportive to instructional practice? If so, how do these impact the instruction of NHTS?; What are different ways to support and strengthen the professional practice of NHTS?

Area: Assessment

Assessment competency requires a teacher to have the knowledge and skills to implement a variety of assessments for student learning, and to be able to use the information gleaned from assessments to guide instruction. Very few studies have examined NHTS knowledge, implementation, and interpreation of assessments.

In a qualitative case study, Kamen (1996) investigated one second-year elementary teacher's use of authentic science assessments. Through interviews and journal reflections, it was determined that certain supports enable the implementation of authentic science assessments such as portfolios, creative drama, student logs, and student choice of assessment. One of these supports was an influential science methods course. Other supports were structural and included time and permission to take risks during science instruction.

More recently, Ruiz-Primo and Furtak (2007) examined three middle school science teachers' formative assessment practices aligned with eliciting, recognizing, and using information. Two of the teachers were NHTS, and one was a 14-year veteran. Measurements of teachers' formative assessment were captured through videotaped observations provided by the participants and student achievement data on multiple-choice tests. The videotaped lessons were coded according to a formative assessment cycle that contained teacher elicitation, student response, teacher recognition of student response, and teacher use of student response. It was found that the two NHTS were more likely to use complete cycles of formative assessment. In addition, the NHTS who most frequently completed cycles of formative assessment had the highest student achievement scores on the post-test.

Area Summary

NHTS knowledge and implementation of assessments remains a consistently under-researched area. As a result, there is a significant amount of research to be conducted in this area. For instance, studies are needed that examine how NHTS use assessments and interpret assessment data, whether formative or summative; how NHTS modify instruction based on formative and summative assessments; and how NHTS learn how to use assessments to support student learning.

Area: Professionalism

Professionalism for NHTS means working effectively with students, parents and colleagues; and involves engagement in professional learning opportunities to improve teacher knowledge and practice. Research that examines the continual commitment to engaging in meaningful learning experiences and working professionally alongside colleagues, parents, and students can be categorized by: growing professionally, inquiring into one's practice, and participating in professional communities.

Growing Professionally

Professional learning is an important part of a teacher's career. Deciding how to engage in various learning opportunities requires that a teacher develop an awareness of his or her strengths or weaknesses as a teacher. There are several studies that explore NHTS experiences, their efficacy beliefs as teachers, or identity development. It is this understanding that ultimately positions the NHTS to engage in strategic professional learning opportunities.

Transitioning. For instance, Mulholland and Wallace (2003a; 2003b) conducted case studies that followed Australian primary teachers from their preservice program to their first years in the classroom. Interviews, observations, journals and others documents were collected and analyzed in order to understand the transition of these newly hired teachers. Both studies document the transition of Katie, or Katie and Ruth, from a non-science position to a position that involved teaching science, from initial certification to in-service teacher, and from teaching all subjects including science. Throughout these transitions, the two teachers were aware of the changes, but found the transitions difficult to make for different reasons.

Efficacy. Internal factors can impact teacher professionalism and learning. One of these factors is efficacy. In a mixed methods study, Haigh and Anthony (2012) considered how teacher efficacy changed in the first 18 months of teaching. They collected survey and interview data on 20 secondary science teachers in New Zealand. As a group, the teachers' efficacy ratings remained constant over this time. However, upon closer inspection of three case studies, changes in efficacy were seen based on context and support for professional learning. One of the teachers struggled and lacked confidence and, as a result, considered teaching part-time in order to have a more balanced life. The second teacher was described as positive, resilient, and self-sufficient, and became more informed and firm in her teaching, which allowed her to continually progress and learn as a teacher. The third teacher changed schools and teaching subjects (from science to physical education and health) at the end of the first year of teaching. With this change, she became less confident because the students were more challenging and the school was less supportive. Overall, all the teachers gained confidence when they felt the students were learning from their teaching. From this study, efficacy connects to teacher confidence.

Identity. Developing a professional science teacher identity is part of the beginning teacher learning process. In one study, Volkmann and Anderson (1998) studied the journal of a first-year chemistry teacher and the processes she went through to develop her professional science teacher identity. The data analysis was a hermeneutical phenomenological approach and it revealed the teacher encountered three dilemmas and tensions between her personal and professional identities. First, she felt like a student, but she needed to act like an adult. Second, she wanted to be a caring teacher, but she also needed to be tough. Third, she felt incompetent in her content knowledge, yet needed to act like an expert. She resolved these dilemmas through metaphors and visualizing herself in different ways. For instance, she visualized herself as being a role model, balancing caring and control, and as human being rather than an excellent teacher. These resolutions allowed her to integrate her personal and professional identities to create her envisioned science teacher identity.

Wassell (2006) studied the identity formation process of a first-year science and mathematics teacher through a narrative inquiry approach. From interviews with students and the teacher, observations of classroom instruction, and analysis of the teacher's journal, it was found that the teacher had established congruence between the type of teacher he wanted to be, and the type of teacher he was. He was able to accomplish this by working closely and identifying with his students, and by continuously reflecting on his own practice.

Varelas, House, and Wenzel (2005) also studied identity formation in NHTS. Three teachers participated in a 10-week summer apprenticeship prior to their first year of teaching, where they worked alongside scientists on research projects. Through this experience, the teachers developed their scientist identities and science teacher identities. For their scientist identities, they engaged in the complexities of science and the collaborative nature of the discipline. However, with their science teacher identities, they were hesitant to engage in the practices of science in their classrooms, and not as willing to work in the collaborative science approach. Therefore, they saw the practice of science teaching as different from the practice of science, which may have resulted in their dual identities.

Bradford and Dana (1996) followed a high school science teacher's thinking about teaching and learning, and its relationship to practice. This case study of a third year teacher utilized interviews and observations in the data collection. The analysis of data revealed that the teacher was focused on her students, wanted her students engaged in science experiences, and that she was committed to improving her own practice. The data also revealed that she was conflicted in the amount of direction she gave the students and her desire to have a student-centered classroom. Therefore, she struggled to balance her identity as a facilitator and drill sergeant.

In another study, Luehmann (2008) conducted an exploratory case study of one middle school NHTS. The fifth-year teacher used blogging over a year as a reflection tool to work through dilemmas and develop her professional identity. Data sources included the teachers' posts in the blog, comments to her posts, email exchanges between the researcher and the teacher, and phone conversations with the teacher's colleagues. In the blog, the teacher consistently wrote about improving her practice aligned with reform-minded teaching. The project helped the teacher develop dispositions, content knowledge, student knowledge, pedagogical knowledge, and allowed her to critically reflect and improve her practice through audience interaction and feedback.

Summary. Each of the above studies on efficacy or identity focused on the internal factors that influence NHTS learning. Efficacy can impact teachers' practice and overall decisions to stay in the career. The studies on identity reveal that there are tensions that arise in NHTS identity formation. These studies recommend teacher educators provide NHTS opportunities to develop teacher efficacy, and experience to reconcile tensions in their professional science teacher identity formations. However, little is known about how to reconcile and integrate identity formation and/or tensions in the first years in the classroom.

Inquiring into one's own practice

Part of growing professionally requires critical reflection on one's own practice. This can be done individually, or through formal programs. It is important for NHTS to recognize the strengths and weaknesses of their practice and use this understanding to improve their practice.

Through university programs. Several studies have focused on inquiring into one's own practice as a NHTS through ongoing learning connected to courses and programs through the university. For instance, Jones, Rua, and Carter (1998) paired seven elementary and middle school NHTS with seven teachers with over five years of teaching experience. All participants were part of a graduate level methods course and the researchers were interested in how the peer-peer interaction influenced teachers' cognitive growth. By scoring pre- and post-concept maps, it was determined that peer mediated learning stimulated teachers' content knowledge growth. In some cases, the expected 'expert-novice' roles did play out, but in most cases the 'expert' position shifted and depended on the topics and individual teachers. All teachers regardless of experience learned through the process.

In a similar approach, Ormond (2011) studied the effects of the early support program (ESP), a two-year mentoring initiative, for 16 newly hired science and mathematics participants in Australia. Each newly hired teacher was paired with an off-campus mentor. Qualitative and quantitative data were collected on the interactions and topics of discussions during mentor-mentee meetings. It was found that on and off campus mentoring provided different types of support. Overall, personal support and teaching skills were sought after at one's school, whereas off-campus mentors assisted the newly hired science and mathematics teachers with their reflection on content, planning, and teaching strategies.

In a different approach, Adams and Krockover (1999) described how the continual commitment of a university teacher preparation program over the course of three years assisted in the professional development of one high school NHTS. The university program consistently used the secondary teaching analysis matrix (STAM) to observe teachers. Prior to the third year of teaching, the NHTS received a copy of the STAM, which then served as a tool for the teacher to consider his own teaching style. In the first and second year of teaching, the teacher was traditional in his instructional approach. However, by the third year, after receiving a copy of STAM, the teacher shifted to a student-centered classroom approach to teaching.

Windschitl, Thompson, and Braaten (2011) followed eleven NHTS into their first year of teaching. The participants were trained in analyzing student work and were supported by a Critical Friends Group (CFG). The student work analysis was aided by developed rubrics and protocols that guided the discussions in the CFG. In this multi-case study approach, data sources included videotaped recordings of the CFG discussions, observations, student artifacts, and interviews. Overall, in the first year, over one third of the NHTS developed components of “expert-like” teaching. NHTS either viewed student misunderstandings as ‘problems with the students’ or as ‘puzzles of practice’. Those NHTS who analyzed the student work from a ‘puzzles of practice’ perspective used the rubric tool more effectively and demonstrated deeper analysis of student work. The study provided evidence that prospective and first-year teachers can productively analyze student work.

Through reflective practice. NHTS also inquire into their own practice through self-reflection or action research projects. For example, Mitchener and Jackson (2012) described how one middle grade NHTS took charge of her own professional learning through a year-long action research project in her second year of teaching. In this qualitative, interpretive study, data collection included action research proposals and final reports, taped recordings of action research seminars, interviews, observations, and teaching evaluations. In the action research learning process, the teacher focused on successfully constructing relevant curriculum for her middle grades science students and was attentive to student learning.

In a similar approach, Sweeney, Bula, and Cornett (2001) studied a first-year chemistry teacher's action research project. In this naturalistic and interpretive study, observations, interviews, and classroom artifacts were collected as data. Through the project, the teacher developed personal practice theories of teaching, some of which included seeing students as scientists, creating a positive learning environment, and challenging students. It was determined that the teacher's subject matter knowledge influenced his professional learning, as did his reflection on science and teaching.

And in a unique study that is draws upon the use of technology, teacher blogging was investigated by Luehman and MacBride (2008). In this study, the blogs of a first year biology teacher and an experienced mathematics teacher were analyzed in order to understand how the teachers used blogging to support and strengthen their classroom instruction. They reported that both blogs involved sharing resources and responding to prompts. However, the first year teacher did not capitalize on the blog to the level of the experienced mathematics teacher. Yet even with the extended use of the blog, the experienced teacher could have expanded its use to further support his classroom instruction. Luehman and MacBride (2008) recognized the limitation of only two subjects, but they contended that this initial data suggested that blogs have the potential to strengthen the practice of a teacher.

Through professional development programs. Professionalism and NHTS has also been described through participating in a science professional development programs. Simon, Campbell, Johnson, and Stylianidou (2011) described the characteristics of effective professional development for NHTS in the UK. The study included ten schools, and within those ten schools, researchers conducted semi-structured interviews with a member of the management team, head of science, the subject mentor, and the NHTS. Combining data from all the interviews, it was determined that the crucial components of effective professional development programs for new teachers included: broadening experiences, building capacity for the future, support, mentoring, and sharing. In particular, the importance of peer observation, feedback, and sharing was emphasized.

Rosebery and Puttick (1998) described a case study of one elementary NHTS who participated in a professional development program that engaged participants in the practices of science. The teacher had just completed her first year of teaching. Through these sessions and watching videos of her own teaching, the teacher was continuously modifying lessons, enhancing her own science learning, reflecting on her science instruction, and considering student learning. While the teacher did still face the challenges of any beginning teacher, the professional development program gave her an opportunity to productively respond to these dilemmas. As a professional learner, the teacher continuously increased her effectiveness, and showed a willingness to improve for her students' learning.

Summary. These studies show different ways in which a NHTS can continue to grow professionally. These learning opportunities can help build the knowledge and skills of a NHTS. Some of the studies emphasize the focus on student thinking and learning to support professional growth. While these are important conclusions, more research is needed into how NHTS become 'professionals.' For instance, is there is a sequence of events that can support teacher learning, or are there some practices that have more leverage than other practices? How do these practices work in combination to influence the beliefs, knowledge, skills or content of a NHTS. Also, what prompts a teacher to engage in action research, or how different types of reflective practices support learning among teachers?

Participating in communities

Professional learning also involves the active participation in professional learning communities. Communities can exist within or outside of a NHTS school context. Such communities enhance the sharing of ideas and help teachers learn to communicate ideas in the science education community. It also helps teachers learn to work effectively with colleagues.

In-school communities. The school as a community is an important factor for NHTS learning. For example, Saka, Southerland, and Brooks (2009) followed two secondary NHTS from the same preparation program into their first year of teaching to see their assimilation into communities of practice. Data sources were questionnaires, interviews, and observations and the data was analyzed through a cultural historical activity theory (CHAT) perspective. One of the teachers remained isolated and individualistic in the first year, and as a result, shifted from student-centered teaching to teacher-centered teaching. However, the second NHTS successfully became an active member of the school community through collaborative participation with teachers in his department and by taking on leadership roles outside of the classroom. His science teaching remained student-centered.

In England, Haggarty, Postlethwaite, Diment, and Ellis (2011) studied a group of 15 newly hired secondary science and mathematics teachers and their mentors in the school workplace context. Seven of these teachers were NHTS. In part they investigated how the mentoring experience helped shape newly hired teachers’ professional development during the first year of teaching. Data sources included interviews with the NHTS about their induction program, observations of teaching, interviews about the observations with the NHTS, and interviews with mentors. All of the data was analyzed for themes. The main theme throughout the data was that behavior management was the prevalent issue of the newly hired teachers, and this was often the focus of mentoring sessions. It was suggested that mentors must develop skills to mentor and move beyond a focus of behavior management, and instead, focus on pedagogical ideas.

Similarly, collaboration with colleagues is an important component to professional learning. In Australia, Appleton (1999) studied a population of 18 elementary teachers and interviewed them in the first 18 months of teaching to find out what makes it easy or difficult to teach science. One of the most prevalent findings was that in order to teach elementary science, the NHTS reported on the importance of collegiality and the priority of science of each of the teachers in the school.

Out of school communities. Communities that support learning can exist beyond the walls of a school. In an evaluation of a program, Roden (2003) describes the importance of collaboration between teachers in a school and science coordinators. This UK project supported 36 newly qualified primary school teachers in their teaching of science, and their school colleagues and local science coordinators. Over the course of two years, the project participants attended workshops and support sessions that supported science instruction. The NHTS and their colleagues reported positive benefits from the program in terms of enacting science at their schools.

Summary. The school context and community have a great impact on NHTS learning and professional development. Understanding the dynamics and structures of a school and the various components of a school community that can support or hinder NHTS learning is important. It is clear that NHTS need supportive colleagues and mentoring relationships that allow them to foster knowledge and skills beyond behavior management. Such a culture of professional learning should be school-wide. However, NHTS can also learn and develop through out of school communities, whether connected to university programs or professional development programs. More research is need in the area of out-of-school community teacher learning. Understanding how informal and formal professional learning opportunities support NHTS will be important to study in upcoming years.

Area Summary

Research on NHTS and professionalism has investigated growing professionally, inquiring into one's own practice, and participating in communities. Three important findings are revealed from this research. First, when considering NHTS learning, it is important to remember cognitive variables such as efficacy and identity that teachers bring. Second, teacher learning does not end upon completion of a degree program at a university. Universities must continue to foster the developing knowledge and skills of NHTS through partnerships and programs with schools. Finally, NHTS learning is greatly impacted by communities of involvement. The more recent research on NHTS and professionalism is attentive to the school community and collaboration and how that affects NHTS learning.

Future research in this area could examine: How NHTS learn to communicate and enact communication skills with parents/guardians; Professional development for teacher and student learning; The role of policy in the professional learning of NHTS; How NHTS overcome challenges and persist within school contexts; How NHTS learn to work collaboratively and effectively in school communities; and more research in contexts outside of the US would help to provide a global view of the professionalism of NHTS.

Area: Equity

Equity is internationally recognized as an important area for teaching and learning, and emphasizes that a teacher understands and respects the diversity of students and creates a learning environment that is accessible to all students. This is a more recent area of research on NHTS, and studies included in this review reveal that this is a focus in US research. Changing demographic patterns, mobility, and globalization have resulted in diverse classrooms around the world. The US research on NHTS and equity reveal perceptions of preparedness, lessons learned, and promising approaches.

Perceptions of preparedness

Preparing NHTS to teach all students is an important component to teacher learning. Additionally, NHTS perceptions of preparedness can influence their teaching.

Zientek and Thompson (2008) investigated how prepared 103 newly hired science and 116 newly hired mathematics teachers felt to teach all students, including those in high poverty settings. Fifty-nine percent of the science teachers had a major in their teaching field, and 96% had more than 18 hours of teaching in their teaching field. A survey addressing teacher preparation was used, and it revealed that the science teachers in the sample held higher scores than did the mathematics teachers in their perceptions of preparedness, self-efficacy, and overall preparedness. In addition, school district poverty level did not influence NHTS scores, but did influence the mathematics teachers' scores. In this study, subject matter knowledge and hours of teaching experience seemed to relate to perceptions of preparedness.

Lessons learned

How NHTS learn to teach science in equitable ways is an evolving area of scholarship. While there is not one right way to approach this task, some studies have shown that certain approaches alone are insufficient. These studies help direct future research on promising approaches.

In one study, Luft and Roehrig (2005) described how having enthusiasm to work in primarily Hispanic secondary school settings was not enough to teach science equitably. Three first-year teachers were ambitious to work in Hispanic settings and were part of an induction program that promoted the use of reform-based science practices. However, through observations and interviews over the course of a year, the teachers' enthusiasm dwindled and they resorted to familiar instructional approaches that were not student-centered.

Another insufficient approach was described by Kern, Roehrig, and Wattam (2012) who explored how a NHTS Asian immigrant's experience influenced his science teaching. This research developed out of the beliefs that immigrant teachers would be successful working with immigrant students. However, from interviews and observations over a year, it was shown that the teacher held traditional beliefs about teaching, and his instruction was lecture-based. The teacher became disappointed in the lack of value some learners and families had for education. He believed hard work lead to success. However, his attitudes and experiences that fostered his success did not necessarily connect with his students. He had a single lens to view students, and this reduced his ability to see learners as individuals.

Summary. These studies show that enthusiasm or similar life experiences are not sufficient to teach science in equitable ways. While these factors are certainly important, they also need to be coupled with a focus on overcoming challenges and commitment to reform-based science teaching that is described in policy documents around the world. These are important lessons learned, but more studies are needed to support or refute these findings.

Promising approaches

The past decade has shown an increased interest in studies that describe successful approaches for NHTS and equity in science education. Some studies focus on providing evidence that NHTS can teach science in equitable ways if the preparation or certification programs espoused equitable science teaching.

Preparation programs. Bianchini, Johnson, Oram, and Cavazos (2003) demonstrated how three first-year secondary teachers from a preparation program that espoused teaching science in equitable ways successfully taught science for all students by focusing on the nature of science and practices of science. Through videotaped lessons and interviews over a year, it was evident that NHTS can transfer what they learned from teacher preparation into practice. The largest constraint for the NHTS was balancing school policies and state standards with equitable science instruction within time constraints.

Similarly, Proweller and Mitchener (2004) described the successfulness of 15 middle school NHTS in an alternative certification program committed to working with urban youth. In this yearlong, qualitative, interpretive study, data sources were interviews, seminar meeting notes, and observation data. Themes from the data showed that the NHTS developed their professional identities by working with the urban youth and remaining open to having their assumptions challenged. As a result, the NHTS successfully combined science knowledge, pedagogy, and students' lives and developed curriculum that was reflective of their students' lived experiences.

Influence of context. While programs should emphasize equitable science teaching, this alone is insufficient as school working context is a major factor in the enactment or not of equitable science teaching. Some research has begun to show how school context influences NHTS progress towards equitable science instruction.

Bianchini and Brenner (2009) followed one newly hired science and one newly hired math teacher through their first two years in secondary classrooms. Both teachers were part of the state mandated induction program that addressed equity. In this qualitative study, data collection came from field notes and videos of the induction seminars, interviews, and three consecutive days of videotaped lessons. The NHTS learned how to align instruction with equity by participation in professional communities, such as working with colleagues at the school. However, collaborating with colleagues does not always guarantee reform-based instruction. In this case, colleagues and prior teacher education courses had more influence than did the induction program.

In an ethnographic study, Bianchini and Cavazos (2007) compared the experiences of two first-year teachers who came from the same preparation program, taught middle grades science, and participated in the same induction program. Both participants chose to work in high need schools; however, they had very different experiences. Data was collected through interviews, observations, and teachers' written work in their first year of teaching and again in their fourth year of teaching. Both teachers excelled in their teacher preparation program, but experienced different supports in their school contexts. The one teacher who had established learning communities in his school context remained student-centered and focused on equity in his instruction and was able to continually professionally develop, whereas the second teacher received little support, was isolated, and had few tools to continue to learn how to teach science in equitable ways.

Similarly, in a critical narrative inquiry approach, Rivera Maulucci (2010a) considered how urban contexts influenced NHTS activation of various resources in order to improve and enhance science instruction for urban youth. In the sample of three teachers, two were newly hired fifth grade teaches. Through observations and interviews, it was determined that the NHTS changed the cultures of their science classrooms with the collaborative support of an on-site mentor who helped them activate resources in science in order to resist the marginalization of science.

Teacher attributes. Additional scholarship regarding promising approaches to teach science in equitable ways considers individual teacher attributes that positively relate to teaching science in equitable ways.

Buck, Mast, Ehlers, and Franklin (2005) described the continual commitment and learning to teach science in equitable ways of one first-year NHTS. Through an action research project, the beginning teacher worked with a team of researchers and graduate assistants from which she received considerable feedback (e.g., how to use visuals, hands-on activities, and cooperative grouping). Observation, teacher and student interviews, and student work were used as data to determine how the first-year teacher improved her teaching strategies for English Language Learners (ELLs). Data from student interviews and work revealed ELL students did increase their understanding of scientific concepts, but at a rate that was lower than their non-ELL peers.

Internal attributes have also been shown to influence science teaching in equitable ways. Rivera Maulucci (2010b) examined the authentic caring of a fifth-grade NHTS. The teacher taught in an urban context, and initially struggled with cultural, social, symbolic resources to teach science in equitable ways. Through a critical narrative inquiry approach, data sources included field notes of from teacher meetings, interviews and observations. The teacher overcame her struggles by establishing authentic caring relationships with colleagues. This increased her confidence, which increased her instances of teaching science in more investigative ways. It was determined that this investigative science pedagogy created more caring relationships between the teacher and her students, and therefore, enhanced student learning.

Summary. Learning to teach science in equitable ways begins with an initial certification program. After initial certification, the support a NHTS receives in a particular school context greatly influences the progress the teacher can make towards equitable science instruction. Collaborative communities are better suited towards supporting equitable instruction. Confounding the support in these areas is the attributes and willingness of a teacher to teach in equitable ways.

While these studies point in certain directions about equitable instruction, they also call for research in this area. For instance, it is unclear if the level of equitable science teaching in the classroom matches the level of the preparation program. That is, components may occur in the classroom context, but not to the degree espoused by the program due to contextual factors. In addition, it is unclear how an orientation towards equitable instruction is cultivated prior to the first years, and during the first years of teaching. Finally, it is not clear how a NHTS can be made aware of equity issues. As NHTS are likely to work in diverse settings, this is a important topic to pursue.

Area Summary

Equity and NHTS is an evolving area of research. With changing demographic patterns across the US and internationally, it will be important to understand how NHTS are prepared and learn how to teach diverse classrooms. In this area, there are some important research areas to pursue. One area pertains to the diversity of equity research among NHTS. In this review, all of the studies were situated in the US. Different countries will have different orientations towards equitable instruction, and these orientations need to be presented internationally.

Another area pertains to understanding the relationship of equitable instruction and the context of the school. Even when the studies revealed that the NHTS demonstrated components of success in equitable science teaching, they still encountered challenges in their schools. Understanding how a school can support or constrain the equitable instruction of a NHTS will be important to understand in upcoming years.

Achieving the International Teaching Standards:

What the Research Says and Needed Research

Within the global community there is a concern about NHTS. Educational standards from different countries pertaining to the performance of NHTS emphasize this concern. These standards reinforce the performance of a NHTS in the areas of content knowledge, classroom instruction, understanding learners, assessment, equitable instruction, and professional orientation. In order to achieve the standards as envisioned, NHTS will need to participate in programs that support their development. These programs should be guided by research, and they should allow the educators involved to contribute to the knowledge base regarding NHTS.

Prior reviews offered some direction to those interested in supporting NHTS. Gold (1996) and Wang et al. (2008) reinforced the importance of mentoring and induction programs in order to support the professional growth of teachers. An oversight of their review was the recognition of how a discipline is embedded in the process of learning how to teach.

Reviews by Davis et al. (2006) and Bianchini (2012) were specific to science teachers, and examined studies in light of issues in the US. Davis et al. (2006) characterized the problems that new teachers of science encountered in the classroom, but focused on teachers of science from their initial certification program to their first years in the classroom. Bianchini (2012) stressed the importance of understanding the context in which a NHTS works. These reviews certainly point to some important conclusions, which are reinforced in this review. However, this review strives to focus on the first five years of teaching and reaches beyond an examination of context.

With this in mind, there are five major conclusions that can be made that cross all of the areas addressed in this review. These conclusions are:

Ongoing professional support is important for NHTS. There is compelling evidence from the studies reviewed that NHTS benefit in the development of their content knowledge, practice, and professionalism as they participate in professional development or professional learning activities. If NHTS are going to achieve the instructional approaches that are envisioned across teacher standards, then they will need support as professional educators.

Context matters. There is no doubt that the context in which the NHTS of works matters to his or her instructional approach, and ultimately success with students. Educators who work with NHTS need to be attuned to the context in which these teachers work, and they need to help NHTS navigate their own vision for science instruction, with the instruction and professional learning that occurs in their school or district.

NHTS are building their knowledge, practices, and professional approach. In the studies reviewed in for this manuscript, it is evidence that the NHTS are modifying all aspects of their practice in their first few years. In some cases, they are impacted by the professional learning opportunities that are provided to them. In other cases, the change in practice or knowledge resides in the interaction the NHTS has with students in a classroom. NHTS are nimble, evolving practitioners that are influenced by prior and current experiences.

A good start is important to a NHTS. Several of the studies in this review reinforce the importance of initial teacher certification coursework. NHTS who participate in programs that build specific knowledge and skills needed in teaching science seem to be able to use these skills in their first years. With additional support in the first years, a NHTS can actualize the approaches emphasized during initial certification.

There are both internal and external factors to consider when working with NHTS. The research in this review reminds those who work with NHTS that there are internal (e.g., identity, self-efficacy), as well as external considerations when working with NHTS. Supporting the growth of a NHTS entails attentions to all of these factors.

From this review, there are also methodological recommendations and several areas that are in need of further study. The methodological recommendations pertain to the process of understanding NHTS, while the areas of study suggest that there is more to be understood about how a NHTS develops in the early years. The recommendations in these areas are:

Studies on NHTS should consist of contrasts. Most of the studies in this review were descriptive studies that described one teacher or a group of teachers. More could be done to understand teacher development by engaging in research that emphasizes contrasts. For instance, studies could examine how different schools impact similar NHTS, or how different levels of content knowledge are enacted in the early years of teaching. While descriptive studies are useful, building a knowledge base about NHTS requires understanding the boundaries and trajectories of development.

There is more to understand about the development of NHTS who are elementary teachers. In certain areas, most of the studies in this review focused on secondary science teachers. Elementary teachers were not often a topic of study in their early years in the areas of content knowledge, and equity. This research is important as elementary teachers often have different knowledge levels for teaching science, and they have different dispositions towards teaching science. Most importantly, elementary teachers often lay a foundation for student learning in science.

Studies are needed in the areas of assessment, learners and learning, and equity. There is an absence of research in the area of NHTS and assessment, learners and learning, and equity. If NHTS are going to achieve these envisioned standards, then there is a need to understand how they develop and enact these areas. With an understanding of how these areas are enacted, those who support NHTS will be able to strategically target their professional development.

Studies are needed that explore different ways to support NHTS. Professional learning opportunities can occur through professional development programs, mentoring, or even study groups. One area of potential professional learning that has been given limited attention pertains to the informal learning environment and emerging technologies. As teachers become more technologically oriented and engaged in the informal settings that provide relevancy, there is a need to understand how to optimize these environments to support teacher learning. These environments offer teachers instantaneous feedback and they offer learning opportunities that are embedded in personal interests. These are two of the most important and under-examined areas when it comes to NHTS.

Research needs to move beyond supporting and examining 'research legends.' Researchers need to challenge the research legends that limit our understanding of NHTS. For example, the focus on the management concerns of NHTS has distracted researchers from the most important work to be done in the field. By focusing on important issues, such as, the instruction of content and student knowledge, management takes a less important role in the life of a NHTS. A focus on content reinforces the importance of teaching for understanding, and reduces the discourse around distractions that should be woven into discourse about teaching science.

From this review, it is evident that NHTS are malleable and can potentially attain standards that are valued globally. However, it is not clear the NHTS are achieving the standards as envisioned or as depicted in this review. There are several areas that are understudied, and there are areas that are studied which don't give a clear indication about the performance of NHTS. Understanding NHTS is an essential task that deserves our utmost attention.

Acknowledgements

This paper was made possible by National Science Foundation grant 0918697, and The University of Georgia Presidential Fellowship. The findings, conclusions, and opinions herein represent the views of the authors, and do not necessarily represent the views of personnel affiliated with the National Science Foundation or the University of Georgia Graduate Program.

References

Abell, S. K. (2007). Research on science teacher knowledge. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education* (pgs. 1105-1150). Mahwah, New Jersey, LEA.

Adams, P. E., & Krockover, G. H. (1997). Beginning science teacher cognition and its origins in the preservice secondary science teacher program. *Journal of Research in Science Teaching, 34*(6), 633-653.

Adams, P.E., & Krockover, G.H. (1999). Stimulating constructivist teaching styles through use of an observation rubric. *Journal of Research in Science Teaching, 36*(8), 955-971.

Alger, G., & Norman-Gloria, C. (2009). Morale of beginning secondary science teachers: A comparative analysis of teacher preparation programs.

Alonzo, A. C., Kobarg, M., & Seidel, T. (2012). Pedagogical content knowledge as reflected in teacher–student interactions: Analysis of two video cases. *Journal of Research in Science Teaching*, *49*(10), 1211–1239.

American Association for the Advancement of Science (AAAS) (1993). *Benchmarks for science literacy*. New York: Oxford University Press.

American Educational Research Association (2006). Standards for reporting on empirical social science research in AERA publications. *Educational Researcher, 35*(6), 33-40. Retrieved from: http://www.sagepub.com/upm-data/13127_Standards_from_AERA.pdf

Anderson, A.M., Dragsted, S., Evans, R.H., & Sorenson, H. (2004). The relationship between changes in teachers' self-efficacy beliefs and the science teaching environment of Danish first-year elementary teachers. *Journal of Science Teacher Education, 15*(1), 25-38.

Appleton, K. (1999). Why teach primary science? Influences on beginning teachers' practices. *International Journal of Science Education, 21*(2), 155-168.

Arzi, H. J., & White, R. T. (2008). Change in teachers' knowledge of subject matter: A 17-year longitudinal study. *Science Education, 92*(2), 221-251.

Ashby, P., Hobson, A. J., Tracey, L., Malderez, A., Tomlinson, P. D., Roper, T., Chambers, G. N., & Healy, J. (2008). *Beginning teachers' experiences of initial teacher preparation, induction and early professional development: A review of the literature* (Research Report DCSF-RW076). London, England: Department of Children, Schools, and Families

Australian Office for Teaching and School Leadership (AITSL) (2013). *Australian professional standards for teachers*. Melbourne, Australia. Retrieved from http://www.teacherstandards.aitsl.edu.au/

Avraamidou, L., & Zembal-Saul, C. (2005). Giving priority to evidence in science teaching: A first-year elementary teacher's specialized practices and knowledge. *Journal of Research in Science Teaching, 42*(9), 965–986.

Avraamidou, L., & Zembal-Saul, C. (2010). In search of well-started beginning science teachers: Insights from two first-year elementary teachers. *Journal of Research in Science Teaching, 47*(6), 661-686.

Bang, E., Kern, A.L., Luft, J.A., & Roehrig, G.H. (2007). First-year secondary science teachers. *School Science and Mathematics, 107*(6), 258-261.

Beyer, C.J, & Davis, E.A. (2008). Fostering second graders' scientific explanations: A beginning elementary teacher's knowledge, beliefs, and practice. *Journal of the Learning Sciences, 17*, 381-414.

Bianchini, J. (2012). Teaching while still learning to teach: Beginning science teachers' views, experiences, and classroom practices. In B. J. Fraser (Ed.), *Second international handbook of science education* (pp. 389-399). New York: Springer.

Bianchini, J.A., & Brenner, M.E. (2009). The role of induction in learning to teach toward equity: A study of beginning science and mathematics teachers. *Science Education, 94*(1), 164-195.

Bianchini, J. A., & Cavazos, L. M. (2007). Learning from students, inquiry into practice and participation in professional communities : Beginning teachers ' uneven progress toward equitable science teaching. *Journal of Research in Science Teaching*, *44*(4), 586–612.

Bianchini, J.A., Johnston, C.C., Oram, S.Y., & Cavazos, L.M. (2003). Learning to teach science in contemporary and equitable ways: The successes and struggles of first-year science teachers. *Science Education, 87*(3), 419-443.

Borman, G.D., Gamoran, A., & Bowdon, J. (2008). A randomized trial of teacher development in elementary science: First-year achievement effects. *Journal of Research on Educational Effectiveness*, 1, 237–264.

Bradford, C.S., & Dana, T.M. (1996). Exploring science teacher metaphorical thinking: A case study of a high school science teacher. *Journal of Science Teacher Education, 7*(3), 197-211.

Brickhouse, N., & Bodner, G.M. (1992). The beginning science teacher: Classroom narratives of convictions and constraints. *Journal of Research in Science Teaching*, *29*(5), 471-485.

Britton, E., Paine, L., Pimm, D., & Raizen, S. (2003). *Comprehensive teacher induction.* Dordrecht, Netherlands: Kluwer Academic Publications.

Brown, S.L., & Melear, C.T. (2006). Investigation of secondary science teachers' beliefs and practices after authentic inquiry-based experiences. *Journal of Research in Science Teaching, 43*(9), 938–962.

Buck, G., Mast, C., Ehlers, N., & Franklin, E. (2005). Preparing teachers to create a mainstream science classroom conducive to the needs of English-Language Learners: A feminist action research project. *Journal of Research in Science Teaching, 42*(9), 1013-1031.

Bybee, R.W. (1982). Historical research in science education. *Journal of Research in Science Teaching, 19*(1), 1-13.

Carter, K., Cushing, K., Sabers, D., Stein, P., & Berliner, D. (1988). Expert-novice differences in perceiving and processing visual classroom information. *Journal of Teacher Education, 39*(3), 25-31.

Clarke, A., Triggs, V., & Nielsen, W. (2013). Cooperating teacher participation in teacher education. *Review of Educational Research.* Accessed online: http://rer.sagepub.com/content/early/2013/09/23/0034654313499618

Council of Chief State School Officers (CCSSO) (2011). *InTASC model core teaching standards: A resource for state dialogue*. Washington, DC: Author. Retrieved from http://www.ccsso.org/Resources/Publications/

Crawley, F. E., & Salyer, B. A. (1995). Origins of life science teachers' beliefs underlying curriculum reform in Texas. *Science Education, 79*(6), 611-635.

Davis, E., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research, 76*(4), 607-651.

Dawson, V. (2008). Use of information communication technology by early career science teachers in Western Australia. *International Journal of Science Education*, *30*(2), 203-219.

Demetriou, H., & Wilson, E. (2009). Synthesising affect and cognition in teaching and learning. *Social Psychology Education, 12,* 213–232.

Demir, A., & Abell, S.K. (2010). Views of inquiry: mismatches between views of science education faculty and students of an alternative certification program. *Journal of Research in Science Teaching,47*(6), 716–741.

Department of Education (2012). Teachers' standards. Cheshire, England: Department of Education/Queens . Retrieved from: https://www.gov.uk/government/publications/teachers-standards

Dreon, O., & McDonald, S. (2012). Being in the hot spot: A phenomenological study of two beginning teachers' experiences enacting inquiry science pedagogy. *Teachers and Teaching, 18*(3), 297-313.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers Record*, *103*(6), 1013-1055.

Findlay, M., & Bryce, T. G. K. (2012). From teaching physics to teaching children: Beginning teachers learning from pupils. *International Journal of Science Education*, *34*(17), 2727–2750.

Fletcher, S.S., & Luft, J.A. (2011). Early career secondary science teachers: A longitudinal study of beliefs in relation to field experiences. *Science Education, 95,* 1124 – 1146.

Forbes, C.R., & Davis, E.A. (2010). Beginning elementary teachers' beliefs about the use of anchoring questions in science: A longitudinal study. *Science Education, 94,* 365 – 387.

Forbes, C.T. (2004). Peer mentoring in the development of beginning secondary science teachers: Three case studies. *Mentoring & Tutoring: Partnership in Learning, 12*(2), 219-239.

Friedrichsen, P. J., Abell, S. K., Pareja, E. M., Brown, P. L., Lankford, D. M., & Volkmann, M. J. (2009). Does teaching experience matter? Examining biology teachers' prior knowledge for teaching in an alternative certification program. *Journal of Research in Science Teaching*, *46*(4), 357–383.

Garofalo, J., Lindgren, R., & O'Neill, T. (1992). Knowledge developed by a high school teacher participating in a physics research experience. *Science Education*, *76*(1), 43–50.

Gilbert, A. (2011). There and back again: Exploring teacher attrition and mobility with two transitioning science teachers. *Journal of Science Teacher Education, 22*(5), 393-415.

Ginns, I.S., & Watters, J.J. (1999). Beginning elementary school teachers and the effective teaching of science. *Journal of Science Teacher Education, 10*(4), 287–313.

Gold, Y. (1996). Beginning teacher support: Attrition, mentoring, and induction. In J. Sikula (Ed.), *Handbook of research on teacher education*, (pp. 548-594). New York: Macmillan.

Greenwood, A. M. (2003). Factors influencing the development of career-change teachers' science teaching orientation. *Journal of Science Teacher Education, 14*(3), 217-234.

Gustafson, B., Guilbert, S., & MacDonald, D. (2002). Beginning elementary science teachers: Developing professional knowledge during a limited mentoring experience. *Research in Science Education*, *32*(3), 281-302.

Haggarty, L., Postlethwaite, K., Diment, K., & Ellins, J. (2011). Improving the learning of newly qualified teachers in the induction year. *British Educational Research Journal, 37*(6), 935-954.

Haigh, M.A., & Anthony, G.J. (2010). Induction and efficacy: A case study of New Zealand newly qualified secondary science teachers. *Journal of Science Teacher Education*, 23, 651-671.

Henry, G.T., Fortner, C.K., & Bastian, K.C. (2012). The effects of experience and attrition for novice high-school science and mathematics teachers. *Science, 335*, 1118.

Howe, E.R. (2006). Exemplary teacher induction: An international review. *Educational Philosophy and Theory, 38*(3), 287-297.

Ingersoll, R. M., & Perda, D. (2010). Is the supply of mathematics and science teachers sufficient? *American Educational Research Journal*, *47*(3), 563-594.

Jones, M.G., Rua, M.J., & Carter, G. (1998). Science teachers' conceptual growth within Vygotsky's zone of proximal development. *Journal of Research in Science Teaching, 35*(9), 967-985.

Justi, R., & van Driel, J. (2005a). A case study of the development of a beginning chemistry teacher's knowledge about models and modelling. *Research in Science Education, 35*, 197-219.

Justi, R., & van Driel, J. (2005b). The development of science teachers' knowledge on models and modelling: Promoting, characterizing, and understanding the process. *International Journal of Science Education, 27*(5), 549-573.

Justi, R., & van Driel, J. (2006). The use of the Interconnected Model of Teacher Professional Growth for understanding the development of science teachers' knowledge on models and modelling. *Teaching and Teacher Education, 22*, 437-450.

Kamen, M. (1996). A teacher's implementation of authentic assessment in an elementary science classroom. *Journal of Research in Science Teaching, 33*(8), 859-877.

Kang, N. (2007). Elementary teachers' epistemological and ontological understanding of teaching for conceptual learning. *Journal of Research in Science Teaching*, 44(9), 1292-1317.

Kern, A.L., Roehrig, G., & Wattam, D.K. (2012). Inside a beginning immigrant science teacher's classroom: An ethnographic study. *Teachers and Teaching, 18*(4), 469-481.

Kind, V. (2009). Pedagogical content knowledge in science education: Perspectives and potential for progress. *Studies in Science Education,* 45, 169-204.

Koch, J., & Appleton, K. (2007). The effect of a mentoring model for elementary science professional development. *Journal of Science Teacher Education, 18,* 209–231.

Lederman, N. G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching, 36*(8), 916-929.

Leite, L., Mendoza, J., & Borsese, A. (2007). Teachers' and prospective teachers' explanations of liquid-state phenomena: A comparative study involving three European countries. *Journal of Research in Science Teaching, 44*(2), 349–374.

Lee, E., Brown, M. N., Luft, J. A., & Roehrig, G. H. (2007). Assessing beginning secondary science teachers' PCK: Pilot year results. *School Science and Mathematics, 107*(2), 52-60.

Loughran, J. (1994). Bridging the gap: An analysis of the needs of second-year science teachers. *Science Teacher Education, 78*(4), 365-386.

Luehmann, A.L. (2008). Using blogging in support of teacher professional identity development: A case study. *Journal of the Learning Sciences, 17*(3), 287-337.

Luehmann, A.L., & MacBride, R. (2008). Classroom blogging in the service of student-centered pedagogy: Two high school teachers' use of blogs. *THEN Journal*, 1-23.

Luft, J.A. (2001). Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education, 23*(5), 517-534.

Luft, J.A. (2009). Beginning secondary science teachers in different induction programmes: The first year of teaching. *International Journal of Science Education, 31*, 2355-2384.

Luft, J.A. (2012). Subject-specific induction programs: Lessons from science. In T. Smith, L. Desimone, & A. Porter (Eds.), *National Society for the Study of Education, 111th Yearbook, volume 2*,(pgs. 417-442). New York: Teachers College Press.

Luft, J.A., Firestone, J.B., Wong, S.S., Ortega, I., Adams, K., & Bang, E. (2011). Beginning secondary science teacher induction: A two-year mixed methods study. *Journal of Research in Science Teaching, 48*(10), 1199–1224.

Luft, J.A., & Roehrig, G. (2005). Enthusiasm is not enough: Beginning secondary science teachers in primarily Hispanic settings. *School Science and Mathematics, 105*(3), 116-126.

Lynch, S., Pyke, C., & Jansen, J. (2003). Deepening understanding of science and mathematics education reform principles: Novice teachers design web-based units using Project 2061's curriculum analysis. *Journal of Science Teacher Education, 14*(3), 193-216.

Marbach-Ad, G., & McGinnis, J.R. (2008). To what extent do reform-prepared upper elementary and middle school science teachers maintain their beliefs and intended instructional actions as they are inducted into schools? *Journal of Science Teacher Education, 19*, 157-182.

McDevitt, T.M., Gardner, A.L., Shaklee, J.M., Bertholf, M.M., Troyer, R. (1999). Science and mathematics instruction of beginning elementary teachers. *Journal of Science Teacher Education*, *10*(3), 217-233.

McGinnis, J.R., Parker, C., & A.O. Graeber. (2004). A cultural perspective of the induction of five reform-minded beginning mathematics and science teachers. *Journal of Research in Science Teaching, 41*(7), 720–747.

McGinnis, J.R., & Simmons, P. (1999). Teachers' perspectives of teaching science–technology–society in local cultures: A sociocultural analysis. *Science Education, 83,* 179–211.

Meyer, H. (2004). Novice and expert teachers' conceptions of learners' prior knowledge. *Science Education*, *88,* 970– 983.

Mitchener, C.P., & Jackson, W.M. (2012). Learning from action research about science teacher preparation. *Journal of Science Teacher Education*, 23, 45–64.

Monteiro, R., Carrilo, J., & Aguaded, S. (2010). Teacher scripts in science teaching. *Teaching and Teacher Education, 26,*1269-1279.

Mulholland, J., & Wallace, J. (2001). Teacher induction and elementary science teaching: Enhancing self-efficacy. *Teaching and Teacher Education*, *17*(2), 243-261.

Mulholland, J., & Wallace, J. (2003a). Crossing borders: Learning and teaching primary science in the pre-service to in-service transition. *International Journal of Science Education, 25*(7), 879-898.

Mulholland, J., & Wallace, J. (2003b). Facilitating primary science teaching: A narrative account of research as learning. *Teachers and Teaching, 9*(2): 133-155.

Mulholland, J., & Wallace, J. (2005). Growing the tree of teacher knowledge: Ten years of learning to teach elementary science. *Journal of Research in Science Teaching, 42*(7), 767-790.

Munby, H., Cunningham, M., & Lock, C. (2000). School science culture: A case study of barriers to developing professional knowledge. *Science Education, 84*(2), 193-211.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academies Press.

New Zealand Teachers Council (2007). *Graduating teaching standards: Aotearoa New Zealand.* Wellington: New Zealand: New Zealand Teachers Council. Retrieved from: http://archive.teacherscouncil.govt.nz/te/gts/index.stm

Ontario Ministry of Education (2010). *Teacher Performance Appraisal Technical Requirements Manual.* Toronto, ON: Queen's Printer for Ontario. Retrieved from: http://www.edu.gov.on.ca/eng/teacher/pdfs/TPA_Manual_English_september2010l.pdf

Ormond, C. (2011). Tailoring mentoring for new mathematics and science teachers: An exploratory study. *Australian Journal of Teacher Education, 36*(4), 53-72.

Park, H., Hewson, P.W., Lemberger, J., & Marion, R.D. (2010). The interactions of conceptions of teaching science and environmental factors to produce praxis in three novice teachers of science. *Research in Science Education, 40*, 717-741.

Patterson, N.C., Roehrig, G.H., & Luft, J.A. (2003). Running the treadmill: Explorations of beginning high school science teacher turnover in Arizona. *High School Journal, 86*(4), 14-22.

Peacock, A., & Gates, S. (2010). Newly qualified primary teachers' perceptions of the role of text material in teaching science. *Research in Science & Technological Education, 18*(2), 155-171.

Peters, E. (2010). Shifting to a student-centered science classroom: An exploration of teacher and student changes in perceptions and practices. *Journal of Science Teacher Education 21*, 329–349.

Powell, R. P. (1997). Teaching alike: A cross-case analysis of first-career and second-career beginning teachers' instructional convergence. *Teaching and Teacher Education*, *13*(3), 341–356.

Proweller, A., & Mitchener, C.P. (2004). Building teacher identity with urban youth: Voices of beginning middle school science teachers in an alternative certification program. *Journal of Research in Science Teaching, 41*(10), 1044-1062.

Rinke, C. R. (2009). Finding their way on: Career decision-making processes of urban science teachers. *Science Education*, *93*(6), 1096–1121.

Ritchie, S.M., Tobin, K., Hudson, P., Roth, W.-M., & Mergard, V. (2011). Reproducing successful rituals in bad times: Exploring emotional interactions of a new science teacher. *Science Education*, *95*, 745 – 765.

Rivera Maulucci, M.S. (2010a). Resisting the marginalization of science in an urban school: Coactivating social, cultural, material, and strategic resources. *Journal of Research in Science Teaching*, *47*(7), 840-860.

Rivera Maulucci, M.S. (2010b). Navigating role forces and the aesthetic authentic caring dialectic: A novice urban science teacher's developmental trajectory. *Cultural Studies of Science Education, 5*(3), 625-647.

Roden, J. (2003). Bridging the gap: The role of the science coordinator in improving the induction and professional growth of newly qualified teachers. *Journal of In-Service Education, 29*(2), 201-219.

Roehrig, G.H., Kruse, R.A., & Kern, A. (2007). Teacher and school characteristics and their influence on curriculum implementation. *Journal of Research in Science Teaching, 44*(7), 883–907.

Roehrig, G.H., & Luft, J.A. (2004). Constraints experienced by beginning secondary science teachers in implementing scientific inquiry lessons. *International Journal of Science Education 26*(1), 3-24.

Roehrig, G.H., & Luft, J.A. (2006). Does one size fit all? The induction experience of beginning science teachers from different teacher-preparation programs. *Journal of Research in Science Teaching, 43*(9), 963–985.

Rop, C. (2002). The meaning of student inquiry questions: A teacher's beliefs and responses. *International Journal of Science Education, 24(7)*, 717–736.

Rosebery, A.S., & Puttick, G.M. (1998). Teacher professional development as situated sense-making: A case study in science education. *Science Education, 82*(6), 649-677.

Roth, W.-M., Ritchie, S.M., Hudson, P., & Mergard, V. (2011). A study of laughter in science lessons. *Journal of Research in Science Teaching, 48*(5), 437–458.

Ruiz-Primo, M.A. & Furtak, E.M. (2007). Exploring teachers' informal formative assessment practices and student's understanding in the context of scientific inquiry. *Journal of Research in Science Teaching, 44*(1), 57-84.

Saka, Y., Southerland, S. A., & Brooks, J. S. (2009). Becoming a member of a school community while working toward science education reform: Teacher induction from a cultural historical activity theory (CHAT) perspective. *Science Education*, *93*(6), 996–1025.

Schneider, R., & Krajcik, J. (2002). Supporting Science Teacher Learning: The Role of Educative Curriculum Materials. *Journal of Science Teacher Education, 13*(3), 221-245.

Shey, C., & Baird, W.E. (1993). Effects of videotaping feedback methods on Taiwan first-year elementary science teachers' teaching skills and attitudes toward teaching science. *Journal of Science Teacher Education, 4*(4), 97-103.

Shugart, S. S., & Hounshell, P. B. (1995). Subject matter competence and the recruitment and retention of secondary science teachers. *Journal of Research in Science Teaching*, *32*(1), 63–70.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*, 1-22.

Simmons, P.E., Emory, A., Carter, T., Coker, T., Finnegan, B., Crockett, D., . . . Labuda, K. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching 36*(8), 930–954.

Simon, S., Campbell, S., Johnson, S., & Stylianidou, F. (2011). Characteristics of effective professional development for early career science teachers. *Research in Science and Technology Education, 29*(1), 5-23.

Simonsen, L., Luebeck, J., & Bice, L. (2009). The effectiveness of online paired mentoring for beginning science and mathematics teachers. *Journal of Distance Education, 23*(2), 51-68.

Smith, L. K., & Southerland, S. A. (2007). Reforming practice or modifying reforms ?: Elementary teachers' response to the tools of reform, *44*(3), 396–423.

Smith, R. G. (2007). Developing professional identities and knowledge: Becoming primary teachers. *Teachers and Teaching: Theory and Practice*, *13*(4), 377-397.

Soares, A., Lock, R., & Foster, J. (2008): Induction: the experiences of newly qualified science teachers. *Journal of Education for Teaching 34*(3), 191-206.

Sweeney, A.E., Bula, O.A., & Cornett, J.W. (2001). The role of personal practice theorys in the professional development of a beginning high school chemistry teacher. *Journal of Research in Science Teaching, 38*(4), 408-441.

Varelas, M., House, R., Wenzel, S. (2005). Beginning teachers immersed into science: Scientists and science teacher identities. *Science Education, 89*(3), 492-516.

Volkmann, M.J., & Anderson, M.A. (1998). Creating professional identity: Dilemmas and metaphors of a first-year chemistry teacher. *Science Education, 82*(3), 293-310.

Wang, J., Odell, S.J., & Schwille, S.A. (2008). Effects of teacher induction on beginning teachers' teaching: A critical review of the literature. *Journal of Teacher Education, 59*(2), 132-152.

Wassell, B.A. (2006). The type of teacher I don't want to be: Constructing teacher identity through converse descriptions and student voice. *Teacher Education and Practice, 19*(2), 149-163.

Williams, J., Eames, C., Hume, A., & Lockley, J. (2012). Promoting pedagogical content knowledge development for early career secondary teachers in science and technology using content representations. *Research in Science & Technological Education, 30*(3), 327-343.

Windschitl, M., Thompson, J., & Braaten, M. (2011). Ambitious pedagogy by novice teachers: Who benefits from tool-supported collaborative inquiry into practice and why? *Teachers College Record, 113*(7), 1311-1360.

Zientek, L.R., & Thompson, B. (2008). Preparing high quality mathematics and science teachers: Are we meeting the challenge? *Mid-South Educational Research Association, 15*(2), 1-19.

Table 3

*Rubric to Review Research Articles**

Criteria	Score = 1.0	Score = 0.5	Score = 0.0	Comment
Research Question or Research Focus	Clearly stated question or focus and relates to theory and/or literature.	Loosely stated and somewhat connects to theory and/or literature.	Absent or poorly grounded in literature and/or theory.	Early studies may not have a clear connection to theory.
Design and Procedures	Detailed information about an appropriate design, and appropriate data collection and analysis process based on the question.	Adequate information is presented, but more information could be provided about the design, data collection or data analysis, or a better design, data collection and analysis process could be used.	Limited or no information provided regarding the design, data collection and analysis.	Limitations in this area may be a result of the page limits of the journals, and the expectations within the field.
Results and Discussion	Claims are well supported by the analysis.	Claims made, but may lack thorough substantiation, or important claims are not made.	Claims step beyond the data, are unsupported, or are not made.	
Contribution to the field	Well-reasoned and justified commentary about the contribution to the field. Clear contribution to the field. Not overstated.	Reasonable contribution to the field, but may lack clear justification or reasoning, or significance.	Limited or no clear contribution to the field specified.	Contributions are often situated within social and political contexts, which change over time.

*Drawn from the work of Clarke, Triggs, and Nielson (2013), and influenced by the American Educational Research Association (2006) research standards, and Bybee's (1982) accommodations for historical research.

Table 4

Areas and Standards in International Documents

Standard Area	Summary	Examples
Content and Curricular Knowledge	Content and Curricular Knowledge require a deep understanding of the content that is to be taught, and an understanding of the curriculum that supports the teaching of the content.	AU: Content and teaching strategies of the teaching area UK: Have a secure knowledge of the relevant subject(s) and curriculum areas, foster and maintain pupils interest in the subject, and address misunderstandings. US: The teacher understand the central concepts, tools of inquiry, and structures of the discipline(s) he or she teaches, and creates learning experiences that make the discipline accessible and meaningful for learners to assure mastery of the content.
Learners and Learning	Learners and Learning requires knowledge of learner development and the process of learning.	AU: Understand how students learn NZ: Have knowledge of a range of relevant theories and research about pedagogy, human development and learning. ON: Teachers demonstrate commitment to the well being and development of all pupils. Commitment to pupils and their learning.
Professional Practice/ Learning Environments	Professional Practice/Learning Environments entails planning and enacting instruction that ensures student learning.	AU: Plan, structure, and sequence learning programs. NZ: Use and sequence a range of learning experiences to influence and promote learner achievement. UK: Manage behavior effectively to ensure a good and safe learning environment. US: The teacher understands and uses a variety of instructional strategies to encourage learners to develop deep understanding of content areas and their connection, and to build skills and apply knowledge in meaningful ways.
Equity	Equity emphasizes that a teacher understands and respects the diversity of students, and creates a learning environment that is	NZ: Demonstrate high expectations of all learners, focus on learning, and recognize and value diversity. ON: Teachers treat all pupils equitability and with respect. UK: Have a clear understanding of the needs of

	accessible to all students.	all pupils, including those with special needs; those of high ability; those with English as an additional language; those with disabilities; and be able to use and evaluate distinctive teaching approaches to engage and support them.
Assessment	Assessment requires a teacher to learn and use different assessment methods to understand the learning of students, and to communicate these with various people about student progress.	ON: Teachers conduct ongoing assessments of their pupils' progress, evaluate their achievement, and report results to pupils and their parents regularly. UK: Use relevant data to monitor progress, set targets, and plan subsequent lessons. US: the teacher understands and uses multiple methods of assessment to engage learners in their own growth, to monitor learner progress, and to guide the teacher's and learner's decision making.
Professionalism	Professionalism involves a teacher working effectively with students, parents and colleagues; and it involves engagement in professional learning opportunities that will improve one's practice.	AU: Engages with colleagues to improve practice ON: Teacher communicates effectively with pupils, parents and colleagues. US: The teacher engages in meaningful and appropriate professional learning experiences aligned with his/her own needs and the needs of the learners, school, and system.

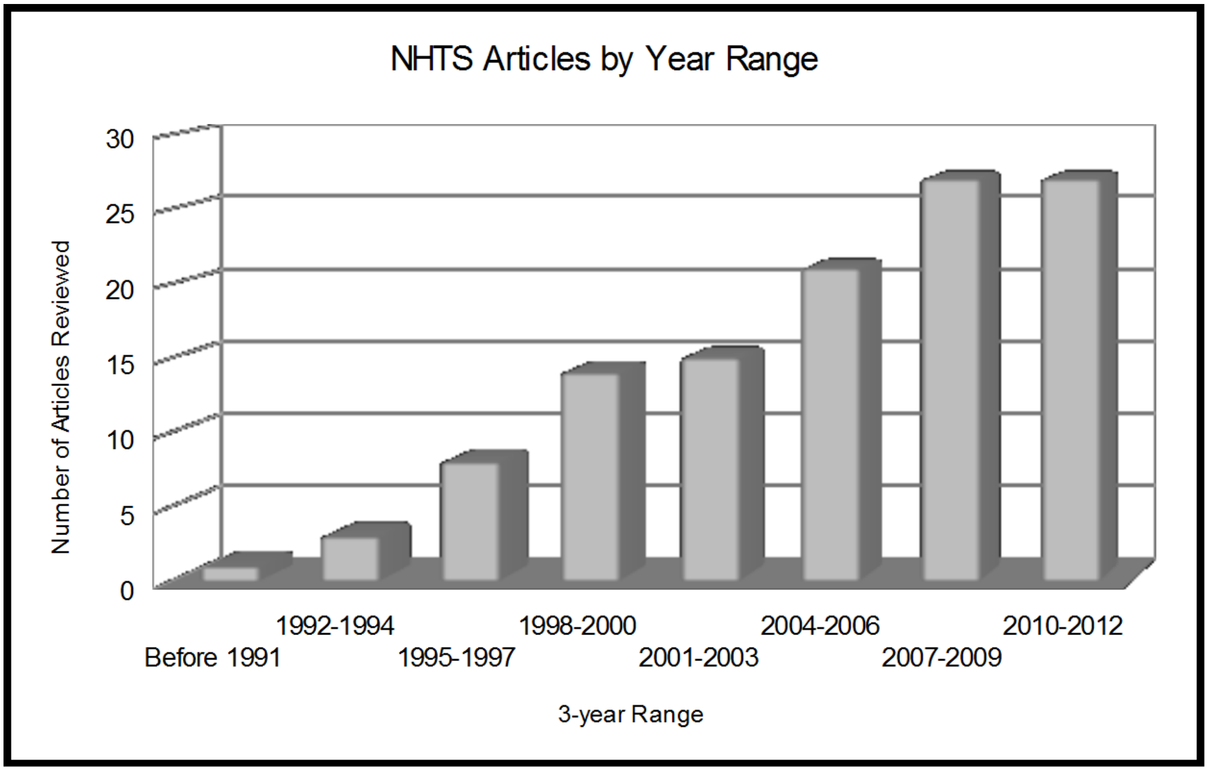

Figure 2. The number of peer-reviewed articles on NHTS that have been published over time, in three year increments.

CHAPTER 5

CONCLUSION

This dissertation explored the experiences of beginning science teachers locally and globally, and focused on the influence of policy on practice. Each of the studies was separate and different, yet each was informative. The overarching question for the dissertation was, "In light of changing policy, how can we better support beginning science teachers to achieve the vision of science teaching that we have for them globally?" Each of the studies provided separate policy level recommendations to help answer the overarching question. This chapter summarizes the implications from each study, discusses the overall contributions, and presents future research directions.

Chapter Implications

The combined implications from this dissertation are for administrators, teacher educators, teachers and policy makers. The implications from each chapter have relative implications for micro, meso, and macro levels of policy. That is, the implications from Chapter 2 are primarily for the micro level, Chapter 3 are primarily for the meso level, and Chapter 4 are primarily for the macro level.

Chapter 2 focused on micro level of school and classroom policies. The data on the first-year floating science teachers showed the influence this phenomenon had on the teachers' instruction. In particular, there was evidence that floating constrained the teachers' implementation of standards-based science instruction. Therefore, the implications of this study were addressed to school and district policy-makers. In particular, principals must consider science teacher location and understand the constraints that accompany floating from class to class. Principals should strategically place beginning science teachers near science colleagues.

Chapter 3 highlighted the importance of considering all levels of policy, but had primary implications for meso level district or state policies. By studying the experiences of beginning secondary science teachers in two different national contexts, attention was given to the larger societal factors that can influence beginning teacher learning. In particular, the data showed the influence of different levels of policy on the planning, teaching, and reflection of the beginning teachers in SA and the US, and the relationships or contradictions among each of the policy levels. More structured approaches towards planning, teaching, and reflection and alignment of the levels of policy in these areas may support beginning teachers to focus on content and student learning.

This chapter had three meso level implications for teacher educators and policy makers. First, the mandated curriculum was an influential factor in the actions of the beginning science teachers. Teacher educators need to provide beginning teachers opportunities to reflect on content and revise their instruction in the midst of changing policies. Policy makers need to consider the influence of changing policies, and work closely with teachers and teacher educators to meet the stated standards. Second, teacher educators need to provide ample opportunities for initial certification teachers to work with students and modify their instruction based on student knowledge. Policy makers need to support beginning teachers' development of knowledge of students and content knowledge beyond initial certification programs. Finally, there needs to be increased communication between teacher educators and policy makers at all levels of the education system.

Chapter 4 focused on macro level policy standards for beginning teachers. This extensive review of literature on NHTS was arranged by the international competency areas of: content and curricular knowledge, learners and learning, professional practice/learning environments, assessment, professionalism, and equity. The overall synthesis showed certain themes across the areas. For example, ongoing professional support is important for beginning science teachers who are developing their knowledge and skills in contextualized settings.

Chapter 4 presented two macro policy implications for teacher educators and policy makers. Since beginning teachers are malleable, they can potentially attain the shared visions in the international standards. However, there needs to be more research and focus on the competency areas of assessment, learners and learning, and equity. It is difficult to say if teachers are achieving these standards or about teacher performance on any of the standard areas. Policy makers should provide opportunities to continue to measure teacher progress towards the standards beyond initial certification programs. Second, teacher educators and policy makers must reinforce the interrelated nature of content knowledge, instruction, assessment, learners, equity and professionalism.

Contributions

Overall, this dissertation has made progress understanding the experiences of beginning science teachers. The studies are connected in that they focus on beginning science teachers and levels of policy. The chapters clearly show the influence of policy on practice, and how practice can inform policy. Additionally, these studies make four other contributions to the field of science education.

The first contribution concerns context, as the meaning and levels of context vary. Chapter 2 looks at context locally and uses CHAT as a theoretical framework to allow researchers to consider components of school context that can influence teacher learning and instruction. However, this is only one way to consider context and the components of CHAT may not be the only contextual factors. Chapter 3 presents a different level of context, as it considers the national contexts of SA and US. Although similarities exist in the standards for beginning teachers in both countries, there are variations in the paths and ways to becoming a teacher and in the policies that influence teacher learning. In cross-national or international work, it is valuable and necessary to consider the variations in national contexts. As Chapter 4 clearly synthesized, context matters in the experiences of beginning teachers. However, as Chapters 2 and 3 showed, context can have varied meanings and researchers must articulate and examine the use and levels of context in research.

A second contribution of this dissertation regards cross-national, comparative, and international research in science education. There have been few cross-national and comparative science education empirical studies, and this dissertation adds insight to this type of research. Chapter 3 qualitatively examined a cycle of instruction with beginning chemistry teachers in SA and the US. The design and implementation of the study was entirely collaborative between researchers in both countries. This provided an example of how research can transcend national boundaries and take science education in new directions. It allowed researchers to look inward and outward (Weiss, 1977) and consider local, national, and global factors that influence science instruction.

The review of literature in Chapter 4 also contributed to an international focus of science education. The framework was purposefully designed to be representative of international standards for beginning teachers. This guided the overall synthesis and structure of the review as it created a globally comprehensive picture of the research that has been conducted, and that still needs to be done. This international perspective can strengthen the understanding of the developing theories of beginning teacher learning.

A third contribution provides insights into the constraints experienced by beginning science teachers. While problems experienced by beginning teachers have been well-documented throughout the literature over time (e.g., Loughran, 1994; Roehrig & Luft, 2004; Veenman, 1984), there are always new constraints arising with rapidly changing educational policies. Chapter 2 illustrated how science teacher location in a school can be a constraint, especially if the teacher does not have a classroom. Chapter 3 showed how rapidly changing curriculum can constrain teachers' instruction by limiting their time to develop standards-based materials.

Chapter 4 synthesized constraints within the international standards for beginning teachers and within the research that has focused on this field of study. The most common constraints revealed by the data in the international review were: isolative workplace conditions (e.g., Gilbert, 2011), challenges with administration (e.g., Patterson, Roehrig, & Luft, 2003) student ability, and classroom management (e.g., Roehrig & Luft, 2004). Methodological research constraints included the limited focus on the areas of assessment, learners and learning, and equity. Additionally, there is a need to explore novel ways to support beginning teachers to foster the development of knowledge and skills that persist through constraints.

The final contribution of this dissertation concerns promising examples of beginning science teachers engaged in practices valued by the scientific community. Each of these chapters showed stories of beginning teachers who persisted through the challenges of the first years in the classroom. In Chapter 2, Elvira and James, despite not having classrooms of their own still persisted to teach science in standards-based ways. Their science-specific induction program and science backgrounds helped and encouraged them to do this. In Chapter 3, Albert and Aubrey were examples of beginning teachers in SA and the US who strived to create student-centered classrooms, despite the overall trends towards traditional teaching with the teachers in both countries. Both of these beginners had strong content knowledge, supportive school environments, and attention to students. These cases provided evidence that content knowledge and support may assist in the implementation of standards-based practices.

In Chapter 4, the literature synthesis revealed beginning teachers were most successful at implementing instruction valued by the scientific community when they were supported beyond their initial preparation years in their school contexts (e.g., Bianchini et al., 2003; Bianchini & Cavazos, 2007; Luft et al, 2011). This type of support can come in a variety of forms. The most promising approaches were both individual and collective and included: creating a community of learners (e.g., Forbes, 2004; Koch & Appleton, 2007; Windschitl et al., 2011), analyzing teaching videos (Alonzo et al., 2012; Shey & Baird, 1993), and using action research to focus on learners and learning (e.g., Kang, 2007; Mitchener & Jackson, 2012).

In summary, this dissertation focused on beginning teachers and contributes to the areas of policy, context, international science education, and constraints and affordances. The contributions are both methodological and empirical and focus on the institutional and personal factors that influence the experiences of beginning science teachers. They all help to enhance an understanding of the teaching and learning of beginning science teachers.

Future Directions

While much progress has been made on the field of beginning science teachers, the review of research shows there are still many unanswered questions. Therefore, my research trajectory will continue in the area of beginning science teacher learning and development. One of the most pressing areas in this field pertains to working within various contexts in order to strengthen the knowledge and practices of beginning science teachers.

There are four future research questions that could address this issue. One question is, "How can programs help support beginning science teachers?" This could be answered through an intervention study that specifically considers types of support for beginning science teachers. An approach could involve an induction program that is science-focused and student-focused, where beginning teachers continue to develop their content knowledge and knowledge of students. This induction program could involve creating communities of practice within a school or region. An alternative approach would be to create a professional development program that connects teachers in different countries. Through online communication, beginning teachers could peer mentor and assist one another in their teaching and learning.

A second research question asks, "How do beginning science teachers activate different resources at different points in their professional trajectories to enhance their teaching and learning?" This research will consider the types of resources (i.e., physical, social, symbolic, strategic, and human) beginning science teachers utilize at different stages in their early formative years. Understanding when and where types of resources are activated will provide direction to developing support programs that work within school contexts.

Aside from support, it would be beneficial to know if there is an order to how teachers build their professional knowledge and practice. That is, a question could ask, "Are there certain areas that beginning teachers draw upon more readily than others?" Considering the competencies for beginning teachers, this could be examined by considering the sequence to instruction and the precursors to practice (e.g., content knowledge is a precursor for assessment).

Finally, a future study will continue to examine the influence of micro, meso, and macro policies on beginning science teachers' instruction. Specifically, a question could ask "How do beginning science teachers balance global, national, and local policies?" Since there are disconnections between levels of policy, this study could examine how teachers balance the tensions and how this influences their teaching and learning.

Conclusion

This dissertation afforded an opportunity for the science education community to understand the experiences of beginning science teachers nationally and internationally. The present research was executed with a goal of considering how micro, meso, and macro policies influence beginning teacher instruction, and how beginning teacher instruction can influence the multi levels of policy. Throughout the dissertation, the dialectical relationships of global to local, policy to practice, and macro to micro demonstrated continuums rather than dichotomies of these constructs.

The findings from the studies indicated that while institutional factors influence teachers' actions, the personal knowledge and experiences held by teachers can shape practice and inform policy. Therefore, it is important to equip beginning science teachers with the knowledge and skills to focus on student learning in science. Such knowledge and skills may persist or adapt with changing contexts and policies.

The studies presented in this dissertation are different, yet all show the importance of considering the global to local continuum when conducting research on beginning science teachers. Global, national, and local pressures will always be present, even if they continuously change. These studies serve as part of an incremental effort to understand all the factors that influence beginning science teacher learning and development.

References

Alonzo, A. C., Kobarg, M., & Seidel, T. (2012). Pedagogical content knowledge as reflected in teacher–student interactions: Analysis of two video cases. *Journal of Research in Science Teaching*, *49*(10), 1211–1239.

Bianchini, J. A., & Cavazos, L. M. (2007). Learning from students, inquiry into practice and participation in professional communities : Beginning teachers ' uneven progress toward equitable science teaching. *Journal of Research in Science Teaching*, *44*(4), 586–612.

Bianchini, J.A., Johnston, C.C., Oram, S.Y., & Cavazos, L.M. (2003). Learning to teach science in contemporary and equitable ways: The successes and struggles of first-year science teachers. *Science Education, 87*(3), 419-443.

Forbes, C.T. (2004). Peer mentoring in the development of beginning secondary science teachers: Three case studies. *Mentoring & Tutoring: Partnership in Learning, 12*(2), 219-239.

Gilbert, A. (2011). There and back again: Exploring teacher attrition and mobility with two transitioning science teachers. *Journal of Science Teacher Education, 22*(5), 393-415.

Kang, N. (2007). Elementary teachers' epistemological and ontological understanding of teaching for conceptual learning. *Journal of Research in Science Teaching*, 44(9), 1292-1317.

Koch, J., & Appleton, K. (2007). The effect of a mentoring model for elementary science professional development. *Journal of Science Teacher Education*, *18,* 209–231.

Loughran, J. (1994). Bridging the gap: An analysis of the needs of second-year science teachers. *Science Teacher Education, 78*(4), 365-386.

Luft, J.A., Firestone, J.B., Wong, S.S., Ortega, I., Adams, K., & Bang, E. (2011). Beginning secondary science teacher induction: A two-year mixed methods study. *Journal of Research in Science Teaching, 48*(10), 1199–1224.

Mitchener, C.P., & Jackson, W.M. (2012). Learning from action research about science teacher preparation. *Journal of Science Teacher Education*, 23, 45–64.

Patterson, N.C., Roehrig, G.H., & Luft, J.A. (2003). Running the treadmill: Explorations of beginning high school science teacher turnover in Arizona. *High School Journal, 86*(4), 14-22.

Roehrig, G.H., & Luft, J.A. (2004). Constraints experienced by beginning secondary science teachers in implementing scientific inquiry lessons. *International Journal of Science Education 26*(1), 3-24.

Shey, C., & Baird, W.E. (1993). Effects of videotaping feedback methods on Taiwan first-year elementary science teachers' teaching skills and attitudes toward teaching science. *Journal of Science Teacher Education, 4*(4), 97-103.

Veenman, S. (1984). Perceived problems of beginning teachers. *Review of Educational Research, 54*(2), 143-178.

Windschitl, M., Thompson, J., & Braaten, M. (2011). Ambitious pedagogy by novice teachers: Who benefits from tool-supported collaborative inquiry into practice and why? *Teachers College Record, 113*(7), 1311-1360.

Weiss, C.H. (1977). *Using Social Research in Public Policy Making*. Lexington, MA: D.C. Heath.