Rowan University

Rowan Digital Works

Theses and Dissertations

5-23-2016

Exploring alternate route science teacher development of pedagogical content knowledge

Kim Feltre
Rowan University

EXPLORING ALTERNATE ROUTE SCIENCE TEACHER DEVELOPMENT OF PEDAGOGICAL CONTENT KNOWLEDGE

by

Kim Tedd Feltre

A Dissertation

Submitted to the
Department of Educational Services and Leadership
College of Education
In partial fulfillment of the requirement
For the degree of
Doctor of Education
at
Rowan University
April 1, 2016

Dissertation Chair: Dr. Issam Abi-El-Mona

Dedication

I would like to dedicate this manuscript to my family and friends who supported my ongoing quest for learning and attainment of this goal. You encouraged me to continually move forward and repeatedly assured me that I could overcome all obstacles. Thank you for keeping me focused, for lifting me up, for always being there, and for making a difference in my life!

Acknowledgements

I would like to express my gratitude to Dr. Issam Abi-El-Mona, for his patience and his tutelage throughout this journey. His expertise, high expectations, and explicitness for revisions promoted deeper learning and understanding of the research process. I would also like to express my gratitude to Dr. Ane Johnson, for her structure, her insight, her conversations, and her leadership throughout this journey. The foundation established during the coursework supported my success. Her ongoing support fostered the attainment of this goal. Thirdly, I would like to express my gratitude to Dr. Anne Catena for providing perspective from someone who has travelled a similar journey. Her insight into the process, background experience with my area of research, and feedback propelled me forward and ensured my success. Lastly, I would like to acknowledge the support of and the quality education provided by the Rowan Department of Educational Leadership. The excellence of the program and learning experiences provided relevant and practical knowledge to be applied to both my research and my practice.

Abstract

Kim Feltre
EXPLORING ATERNATE ROUTE SCIENCE TEACHER DEVELOPMENT OF PEDAGOGICAL CONTENT KNOWLEDGE
2015-2016
Issam Abi-El-Mona, Ph.D.
Doctor of Education

The purpose of this qualitative case study was to understand how alternate route first year science teachers' learning experiences gained from their alternate route courses translated into their classroom instruction and facilitated the development of their pedagogical content knowledge. Participants included three first year high school teachers from two alternate route program institutions. Data collection and analyses focused on semi-structured interviews, classroom observations, and teacher-generated artifacts. Findings reveal patterns among participant responses that emphasized the limited translation of learned pedagogical experiences from their alternate route programs into classroom instruction. In addition, findings show that participant alternate route program learned pedagogical experiences were not perceived to have attributed to participants' pedagogical content knowledge. Triangulation of data indicated two main themes that contributed to limited translation of participant learned experiences into their classroom teaching; relevance and reflection. Findings from this study inform understandings of how teacher participant learning experiences from alternate route programs translated to classroom practice and in turn, facilitated teacher pedagogical content knowledge development in novice teachers.

Keywords: alternate route, teacher development, pedagogical content knowledge

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

List of Tables

Chapter 1

Context of Study

Since the 1980's, there has been a call for improved science and mathematics education (National Academies Press, 2007; National Center for Education Statistics, 2011; National Center for Education Statistics, 2012; National Commission on Excellence in Education, 1983; National Research Council, 2007; OECD, 2011; U.S. Department of Education, 1999; U.S. Department of Education, 2007). In response to this call for educational reform, professional development resources and books were written to assist in building the capacity of teachers to improve their science and math instructional practices (Keeley, 2005; Keeley & Rose, 2006; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010; Michaels, Shouse, & Schweingruber, 2008; Mundry, Keeley, & Landel, 2010). A continued focus on effective professional development of and learning by teachers is warranted because the "efforts to improve student achievement can succeed only by building capacity of teachers" (Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009, p. 7). Additionally, teacher quality has a powerful influence on student achievement (Leithwood, Louis, Anderson, & Wahlstrom, 2004; Wei, Darling-Hammond, & Adamson, 2010). While professional learning, if sustained over time, can have a powerful effect on teacher skills and knowledge and consequently on student learning, (Killion, 2002; Kreider, 2006; Wei et al., 2009), "little is known about the mechanisms through which professional development works to improve instruction" (Epstein, 2004, p. 157).

Alternate Route Teachers

Moreover, science and math teaching positions are difficult to retain with teachers who earn their teacher certification through the traditional methods due to high attrition and migration rates (Ingersoll & Perda, 2010). The problem of retention, coupled with problems of quality from traditional undergraduate teacher preparation programs in the 1980s, sparked the establishment of New Jersey's alternate route program for teacher certification in 1984 (Klagholz, n.d.). Goldhaber and Brewer (2000) and Klagholz (2000) define an alternate route teacher as a person who graduated from college with a degree other than education and who transitioned to teaching in a classroom without formal training in education besides that required to obtain a provisional license to teach. For example, a person might have a degree in chemistry but no coursework in education. Alternate route programs provide an expedient means for career-changers to enter the teaching profession. Alternate route teachers can receive from 24 hours to up to 8 weeks of teaching preparation prior to beginning full-time teaching and that preparation continues part-time during their first year of employment as a teacher (Johnson, Birkeland, & Peske, 2005). In New Jersey, each alternate route certification applicant is required to: (1) obtain a baccalaureate degree with a major in the subject to be taught; (2) demonstrate subject competency by passing the relevant subject test of the Praxis II Exam[1]; and (3) acquire and demonstrate teaching skill by completing a mentor-assisted, school-based internship (Certificate Subject Area/Grade Level & Codes, n.d.; Klagholz, 2000). A certificate of eligibility is issued once an alternate route candidate meets all the requirements for the specific endorsement and the certificate of eligibility authorizes the

[1] The Praxis II Exam measures subject-specific content knowledge, as well as general and specific teaching skills necessary for beginning teachers (Educational Testing Service, 2014).

candidate to seek and accept employment in a New Jersey public school (State of New Jersey Department of Education, 2010). Upon obtaining a certificate of eligibility and gaining full-time employment, the alternate route teacher receives support from a mentor teacher during the initial year of teaching while completing course work at an alternate route program training site (Certificate Subject Area/Grade Level & Codes, n.d.; Klagholz, 2000). School administration monitors and evaluates the alternate route teacher's development and classroom performance, and at the end of the year, recommends whether or not the state should issue standard certification to the candidate (Certificate Subject Area/Grade Level & Codes, n.d.; Klagholz, 2000).

The National Center for Alternative Certification (2010) cited that "approximately one-third of new teachers being hired are coming through alternative routes to teacher certification" (National Center for Alternative Certification, 2010, Introduction, para. 1). According to data provided by the New Jersey Department of Education, the percentage of alternate route science teachers over the last ten years ranged from 33% to 69% with the average indicating that alternate route science teachers comprised 54% of the science teaching pool over the last ten years (R. Higgins, personal communication, September 3, 2014). Feistritzer (2009) asserts that the success of alternate route programs is due to the fact that they "are market-driven. They have been created all over the country to meet [the] demand for specific teachers in specific subject areas at specific grade levels in specific schools where there is a demand for teachers" (Feistritzer, 2009, p. 4).

Corroborating these findings, a report by the U.S. Congress Joint Economic Committee regarding Science, Technology, Engineering and Mathematics (STEM) education (2012) states "that it is challenging to attract and retain STEM-trained individuals to teach STEM subjects at the K-12 level" (U.S. Congress Joint Economic Committee, 2012, p. 8). Feistritzer (2009) reported that "in the sciences, including biology, geology, physics, and chemistry, 28 percent of alternate route teachers … teach science subjects" (Feistritzer, 2009, p. 11).

Although alternate route science teachers have taken more courses in their content discipline in comparison to science teachers who completed traditional teacher education programs, alternate route teachers lack the pedagogical training that teachers use to promote student learning. For example, an alternate route science teacher who has a Bachelor's degree in science may have taken sixty credits in their science major with no pedagogical training, while a science teacher from a traditional education program may have taken thirty science credits and thirty teaching credits. Alternate route science teachers with Master's degrees or PhD degrees have taken even more science courses as they focused their study of science. As such, it is important for educational institutions in general, and administrators who support teacher development in particular, to better understand the factors that support alternate route science teachers in developing into effective teachers.

Promoting Science Literacy

With the recent attention to and focus on how the United States performs against nations around the world, as indicated by our performance in math and science on the National Assessment of Educational Progress (NAEP) and Trends in International Mathematics and Science Study (TIMSS) (National Center for Education Statistics, 2011), as well as the changing focus of the 2009 science standards (New Jersey Department of Education, 2009a) to a focus on new national standards in science (Next

Generation Science Standards, 2011), an understanding of how the learning experiences science teachers bring to the classroom impact student achievement to promote science literacy is necessary to advance student achievement on the international level.

Due to the growing concern over the United States' lack of performance on national and international assessments such as the NAEP and TIMSS, reform in science education is focusing on building science literacy (American Association for the Advancement of Science, 1990; Michaels et al., 2008; National Research Council, 2007; Sadler, 2006). A *Framework for K-12 Science Education* (National Research Council, 2012) states that

> the committee thinks that developing a scientifically literate citizenry is equally urgent. Thus the framework is designed to be a first step toward a K-12 science education that will provide *all* students with experiences in science that deepen their understanding and appreciation of scientific knowledge and give them the foundation to pursue scientific or engineering careers if they so choose. (National Research Council, 2012, p. 298)

In order to do so, it is important to understand how teachers' experiences can promote scientific literacy in the classroom and what teacher learning experiences best promote science literacy. One component of this study is to understand how alternate route science teachers' alternate route program learning experiences translate to teacher pedagogical choices in the classroom and in turn, promote science literacy.

Epistemic Nature of Science

The social collaborative epistemic nature of science is to argue for the purpose of building sound theories for the collective good of the enterprise; to build consensus based on evidence (Bricker & Bell, 2008; Thier, 2010; Zembal-Saul, 2009). Scientific argumentation supports the sociocultural perspective of learning (Vygotsky, 1978). It does so because scientific argumentation "situates learners and learning in a community that is guided by norms of practice and discourse that reflect particular aspects of scientists' science, including ...the coordination of claims with evidence...as learners publicly participate in negotiating meaning" (Zembal-Saul, 2009, pp. 691-692).

Science is a community-based endeavor in which new scientific conjectures are not accepted or publicly acknowledged until they have been discussed and checked by the scientific community (Newton, Driver & Osborne, 1999). "Scientists challenge and validate one another's ideas in order to advance knowledge" (Michaels et al., 2008). Since scientists engage in collaborative work, engaging in argumentation is one means to provide students with opportunities to develop an appreciation for the epistemic nature of science. The epistemic nature of science includes collaboration, argumentation, explanation, and modeling, with argumentation being a core epistemic practice of science (Hand, Norton-Meier, Staker, & Bintz, 2009; National Research Council, 2007). Engaging in scientific argumentation facilitates students' learning how to craft, identify, and evaluate scientific arguments (Bricker & Bell, 2008; Hand et al., 2009).

Pedagogical content knowledge (PCK) is knowledge of the subject matter for teaching (Shulman, 1986). Teachers with well-developed PCK understand student preconceptions and misconceptions about the content being taught, what makes the content difficult, as well as how to design lessons to make the content comprehensible to the students (Shulman, 1986). Pedagogical content knowledge distinguishes science teachers from scientists and those who know science, based on how the knowledge is used and organized (to promote student learning versus application to a scientist's career). Additionally, PCK differentiates novice teachers from expert teachers (Park & Oliver, 2008; Shannon, 2006; van Driel, Verloop, & de Vos, 1998). Consequently, it is important to understand how to develop and support PCK in alternate route science teachers and in turn, promote science literacy and student achievement.

Problem Statement

A lack of success in science education and competitiveness has global and economic implications for the United States (Darling-Hammond, 2010). Based on the national and state focus on student performance in science, in conjunction with the role that alternate route science teachers play in the teaching pool, it is important to understand how to support the development of alternate route science teachers. It is critical to understand how alternate route science teachers' learning experiences translate into instructional practices, and how alternate route science teacher pedagogical content knowledge develops as a result of alternate route science teachers' learning experiences in their alternate route program.

Purpose Statement

The purpose of this qualitative instrumental case study was to investigate how alternate route science teachers' learning experiences in their alternate route program were translated to their classroom practice and facilitated the development of their pedagogical content knowledge. Through the use of Shulman's (1986) theoretical framework on PCK, in conjunction with adult learning theory and sensemaking theory, this research generated an understanding of what learning experiences are available to alternate route science teachers in their alternate route preparation program. Additionally, this research explored which learning experiences, from their alternate route program, alternate route science teachers translated into practice. Thirdly, this research sought to understand how alternate route science teacher learning experiences facilitated their PCK development. This research did not focus on the beliefs teachers had regarding the value of their alternate route experience. The setting was the New Jersey alternate route programs that enroll students seeking science teacher certification in New Jersey. Participants in this study were first year alternate route science teachers chosen through purposeful sampling. Data collection included semi-structured interviews, teacher-generated artifacts, observations, and field notes, in an effort to understand how alternate route science teachers' learning experiences facilitated their pedagogical content knowledge development.

Research Questions

The research questions that guided this study are:

1. What aspects or learning experiences offered by an alternate route program translate into first year science teachers' classroom teaching?
2. In what way(s) do alternate route science teachers' learning experiences translate into instructional practices?
3. What elements contribute to alternate route science teachers' learning experiences that in effect, facilitate the development of their pedagogical content knowledge?

Theoretical Framework

To address the purpose of this study, it was essential to understand how teacher participants made sense of the pedagogical experiences they learned from their alternate route program, and how such experiences translated into their classroom instruction. This study relied on varied theoretical frameworks in order to gain a holistic understanding of the experiences to which participants were exposed. To this end, methodology and data analysis relied on the use of adult learning theory (Loucks-Horsely et al., 2010) and sensemaking theory (Weick, Sutcliffe, & Obstfeld, 2005, Weick, 2012), in conjunction with Shulman's (1986) theoretical framework on pedagogical content knowledge (PCK). These frameworks were used to understand teacher participant experiences and how teacher participants made sense of those experiences.

Shulman's (1986) theoretical framework on PCK was used to inform the design of the research questions and was the lens through which data was collected, analyzed and interpreted. According to Shulman (1986), teacher experiences are centered on their mastery of three types of knowledge (a) content, also known as "deep" knowledge of the subject itself, and (b) pedagogical content knowledge (i.e. content knowledge beyond subject matter that Shulman describes as the content knowledge for teaching) and (c) knowledge of the curricular development. This study focused on understanding alternate route teachers' learning experiences by focusing on their pedagogical content knowledge as an assumed by-product of the alternate route program they experienced. Shulman's (1986) theoretical framework on PCK was used in the design of the interview questions and observation protocol to collect data on how adult learning and sensemaking facilitated the development of PCK among alternate route science teachers. As such, data tool designs focused on how adult learning and sensemaking facilitated the development of PCK among alternate route science teachers.

In addition to the above theoretical lenses, alternate route science teachers' espoused theories and theories-in-action (Argyris & Schön, 1974) were explored to elucidate how changes in beliefs, as a result of professional learning, translated to change in practice for alternate route science teachers. This served as a means to better understand how alternate route science teachers' PCK developed.

Pedagogical content knowledge. In light of the fact that alternate route science teachers do not have formal teaching experiences prior to their placement in a classroom, their lack of teaching experience may or may not impede their effectiveness as teachers in the classroom. To date, research in this area is inconclusive. Shulman (1986) conceptualized and defined pedagogical content knowledge (PCK) as the knowledge of subject matter *for teaching* (Shulman, 1986, p. 9). PCK includes teacher understanding of student preconceptions and misconceptions about the subject matter, as well as what makes the learning of specific topics easy or difficult (Shulman, 1986). Additionally, to promote student achievement, PCK for teachers must include appropriate strategies to promote student acquisition of the learning outcomes in a lesson (Bransford, Brown, & Cocking, 1999; Shulman, 1986).

Park and Oliver (2008) identified that PCK development incorporates knowledge acquisition and knowledge use, such that teachers develop PCK through a dynamic relationship between knowledge acquisition, new applications of that knowledge, and reflection on the uses of that knowledge in practice. Park and Oliver (2008) found that teachers produce PCK through their own teaching experiences and the most powerful changes to their PCK are a result of these experiences in practice.

Being that subject matter knowledge and teaching experience play a role in PCK development, understanding a prospective teacher's PCK readiness, how their existing PCK will be applied to their teaching, and which learning experiences or elements of learning experiences help to develop their PCK are critical for ensuring greater success of alternate route science teachers. In turn, greater success in the classroom may reduce attrition and promote greater alternate route science teacher retention.

This research was grounded in the framework for PCK, and as such, PCK was used in the design of the research questions, as well as informed the design of the interview and observation questions. Additionally, data was collected, analyzed and interpreted through the lens of PCK. The subcomponents of PCK were used as a priori codes for data analysis. Park and Oliver's (2008) conception of PCK was used for this research, as they have designed several tools for collecting data about PCK, as well as techniques for analyzing the presence of PCK during observations and interviews.

Identifying the learning experiences that promote PCK for alternate route science teachers can assist those who support alternate route science teachers in designing learning experiences to promote the development of alternate route science teachers' PCK, and in turn, promote student achievement. By looking in depth at which and how alternate route science teachers' learning experiences facilitated their pedagogical content knowledge development, it is possible that the conclusions from this study could identify elements of alternate route programs that facilitate teacher effectiveness.

Adult learning theory. Since alternate route science teachers have not had pedagogical training prior to entering a classroom, they need professional learning experiences in order to understand the needs of their students, so as to facilitate student learning (Darling-Hammond, Austin, Orcutt, & Rosso, 2001; Davis, 2003; Spang, 2008). Since alternate route science teachers do not have the teaching experiences from which to develop their ideas and skills for masterful teaching in the classroom, and since “contemporary learning theory recognizes the role that both experience and reflection play in the development of ideas and skills” (Darling-Hammond et al., 2001, p. 9), a key feature to alternate route science teacher PCK development would be the professional learning experiences from which they draw when formulating new ideas for teaching.

For teachers, integrating theory into practice to develop their PCK is an iterative process of evaluating specific classroom situations, student interactions with the content, and determining when and how to use their professional learning experiences to inform a change in practice (Darling-Hammond et al., 2001; van Driel, Verloop, & De Vos, 1998; van Driel, De Jong, & Verloop, 2002). Learning is an active process of using new knowledge to build upon prior knowledge, which emanates from interaction with ideas and phenomena, and involves a process of change when situated in meaningful and relevant contexts (Bransford et al., 1999). Adult learning is a cycle promoted through purposeful design of a learning environment that progresses through invitation to learn, or engagement, to experience, to reflection, and evaluation (Loucks-Horsley et al., 2010).

This research looked through the lens of adult learning to generate an understanding of how alternate route science teachers’ PCK developed, as evidenced by how alternate route science teachers translated their alternate route program learning experiences into practice to promote student learning. Knowledge of adult learning theory also helped discern the systems of adult learning or particular learning experiences that alternate route science teachers perceived to promote their PCK development.

Sensemaking theory. Weick (1995) and Weick, Sutcliffe, and Obstfeld (2005) describe sensemaking as a process of socially constructing plausible meanings that rationalize action that occurs when discrepant cues interrupt a person’s ongoing activity.

This study's research problem and research questions were informed by looking through the lens of sensemaking theory. The goal of this study was to understand how alternate route science teachers make sense of professional learning experiences and translate these experiences into practice in order to develop their PCK; and as such, sensemaking theory guided this understanding. The lens of sensemaking theory helped inform assertions regarding how alternate route science teachers made sense of their adult, professional learning, in order to develop as teachers. In addition, sensemaking theory helped apprise this researcher of the means by which sensemaking assists alternate route science teachers in the development of their PCK. As a researcher conducting a case study, interpretations are built upon making new meanings and making sense of observations, to generate understanding of the experiences of alternate route science teachers (Stake, 1995).

Alternate route teachers who have been trained in science have to make sense of teaching in order to effectively teach their students. Sensemaking is "a largely invisible, taken for granted social process" (Weick, Sutcliffe, & Obstfeld, 2005, p. 417). As such, this study aimed to make visible alternate route science teachers' sensemaking of their learning in their alternate route programs and the connections alternate route science teachers made between their alternate route program learning experiences and their classroom practice. Understanding the sensemaking of learning by alternate route science teachers led to understanding of "the ways in which people redeploy concepts" (Weick, 2012, p. 151) (in this case, translating professional learning into practice to develop PCK). Understanding which alternate route program learning experiences promoted PCK development can help educational leaders support the development of alternate route science teachers' PCK by providing a developmental continuum of professional learning experiences which promote sensemaking, and subsequently promote PCK development in these teachers (Huebner, 2009).

With the focus on improving science education to ensure the United States remains an economic force in the world, it is imperative to understand how teachers develop, as well as how professional learning translates to classroom practice and facilitates PCK development and subsequently, promotes effective instruction in the classroom.

Significance of the Proposed Research

Understanding how alternate route science teachers' alternate route program learning experiences inform their classroom practice and how these alternate route program learning experiences help promote PCK development in alternate route science teachers will assist supervisors, principals, and districts in building the capacity of alternate route science teachers to improve student learning in science. The fact that alternate route science teachers comprise roughly 54% of the teaching pool in New Jersey, and they have not had any extended formal pedagogical training to connect prior knowledge of subject matter to student learning prior to their first year of teaching, understanding how alternate route science teachers' learning experiences in their alternate route program translate to classroom practice and facilitate PCK development will inform those who provide support to these teachers as to how to facilitate their growth as teachers (R. Higgins, personal communication, September 3, 2014). Understanding how to assist alternate route science teachers in developing into effective teachers is critical for promoting student literacy and advancing U.S. academic standing on international assessments. The following pages expand upon the significance of this research in reference to policy, practice, and research.

Policy. Since the alternate route program was one means to increase the number of science teachers in the teaching pool, understanding how alternate science teachers' alternate route program learning experiences are translated into classroom practice and facilitate their PCK development can help inform policy decisions regarding supporting alternate route science teachers during their first years of teaching (Feistritzer, 2009; Grossman & Loeb, 2010; Kee, 2012).

As a student, science teacher, and now a science supervisor, this researcher has witnessed the avocation for education reform in the United States, particularly a call for increased student performance in science, technology, engineering, and mathematics (STEM). Since the 1980s, the media, business, and political leaders consider public education to be in crisis (Fowler, 2009). This concentration on educational reform in STEM is fueled by attention to and focus on how the United States performs against nations around the world on the Programme for International Student Assessment (PISA) and TIMSS (National Center for Education Statistics, 2011; OECD, 2011). The U.S. ranked 17th out of 34 Organisation (*sic*) for Economic Co-operation and Development (OECD) countries for science and 25th for math on the PISA (Huff Post Education, 2011, May 25). According to the TIMSS results, at the end of secondary schooling (twelfth grade in the U.S.), U.S. performance was among the lowest in both science and mathematics, including among our most advanced students (U.S. Department of Education, 1999). A lack of success in STEM education and competitiveness has global and economic implications for the United States.

Educational reform in STEM can also be seen in the changing focus of the 2009 science standards towards a reform that is instituting new national standards in science known as the Next Generation Science Standards or NGSS (New Jersey Department of Education, 2009a; Next Generation Science Standards, 2011). The Common Core State Standards in English Language Arts have standards in informational text for grades K-5 and standards in science and technical subjects for grades 6-12 (Common Core State Standards Initiative, 2011). Additionally, there are efforts at the state level to promote educational reform in STEM. For example, New Jersey is working on developing a STEM Education Innovation campaign in order to pool resources and create a robust system for professional development, all of which will be useful for the adoption of the NGSS (Next Generation Science Standards: New Jersey, 2011, Commitment, para. 1).

Since the publication of the 1983 report *A Nation at Risk*: *The Imperative for Educational Reform*, science and mathematics education has been targeted for improvement (National Commission on Excellence in Education, 1983). As such, federal and state legislation has been enacted over the years to influence how public schools function. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (National Academies Press, 2007) made recommendations to improve STEM education through improving the supply of new STEM teachers, improving the skills of current STEM teachers, enlarging the pre-collegiate pipeline, increasing postsecondary degree attainment, and enhancing support for graduate and early-career research.

There is a federal and a state call for replacing traditional lecture-based teaching strategies with inquiry and project-based pedagogy; a call for having students engage in practices that are authentic representations of the work of scientists and engineers (Breiner, Harkness, Johnson, & Koehler, 2012; Michaels et al., 2008; National Research Council, 2007; New Jersey Department of Education, 2009b). President Obama has spoken about increasing STEM in the United States curriculum (Mervis, 2010) and there is a push for creating (revising) national science standards that would be much like the Common Core Standards to further promote STEM in the states that participate in adopting the Next Generation Science Standards (NGSS) (Next Generation Science Standards, 2011). Based on the national and state focus on student performance in STEM areas, it is important to understand how policy can best promote STEM literacy.

STEM education policy impacts education since many U.S. stakeholders view STEM as a way to heed “the call for creating better prepared high school and college graduates to compete globally” (Breiner et al., 2012, p. 3). STEM education reform can lead to graduating more students with STEM degrees so that the U.S. can remain an innovative leader, maintain its competitive edge, and not fall behind emerging countries. By understanding which alternate route program learning experiences translated to practice and, in effect, promoted PCK development of alternate route science teachers, this research can inform policy surrounding alternate route programs and the learning experiences they provide to support and promote alternate route teacher development and effectiveness. Likewise, findings from this research could inform policy surrounding the design of learning experiences for traditional route teacher preparation programs.

Practice. “There is a significant gulf between classroom practices that are ‘changed’ and practices that actually lead to greater pupil learning; the potency of leadership for increasing student learning hinges on the specific classroom practices that leaders stimulate, encourage and promote" (Leithwood & Jantzi, 2006, p. 223). Understanding alternate route science teacher PCK development and how their learning experiences in an alternate route program promote their PCK development will enable leaders of alternate route science teachers to better support the retention and success of these teachers. Additionally, findings from this research can inform the development of higher education teacher preparation programs.

Professional development of teachers in general, and science teachers in particular, has been targeted since the quality of U.S. education has been questioned (National Academies Press, 2007; National Commission on Excellence in Education, 1983; National Research Council, 2007; National Center for Education Statistics, 2011; National Center for Education Statistics, 2012; U.S. Department of Education, 1999; U.S. Department of Education, 2007). Due to the fact that alternate route science teachers have not taken coursework in pedagogy prior to the start of teaching, professional development targeting pedagogy is a prime way that alternate route science teachers could acquire pedagogical knowledge. Knowledge of how alternate route science teachers translate their learning experiences to classroom practice can inform which professional learning opportunities foster the development of alternate route science teachers' PCK.

Science professional resources focused on science education pedagogy have been designed as a means to augment teacher quality (Keeley, 2005; Keeley & Rose, 2006; Loucks-Horsley et al., 2010; Michaels et al., 2008; Mundry et al., 2010). Science professional resources focused on science education have been designed as a vehicle to address the verdict that "efforts to improve student achievement can succeed only by building capacity of teachers" (Wei et al., 2009, p. 7). With the focus on improving science education to ensure the United States remains an economic force in the world, it is imperative to understand how teachers develop, as well as understand how professional learning translates to PCK development and subsequently, effective instruction in the classroom.

A lack of success in science education has global and economic implications for the United States competitiveness (Darling-Hammond, 2010). Based on the national and state focus on student performance in science, in conjunction with the role alternate route science teachers play in the teaching pool, it is important to understand how to support the PCK development of alternate route science teachers so that they can effectively contribute to heeding “the call for creating better prepared high school and college graduates to compete globally” (Breiner, et al., 2012, p. 3). Since PCK development serves as an indicator of teacher effectiveness, findings from this study can inform support of the development and subsequent effectiveness of alternate route science teachers in the classroom (Friedrichsen et al., 2009; Spang, 2008; van Driel et al., 1998, 2002). As such, it is important to understand how alternate route science teachers’ learning experiences translate into instructional practices, and how alternate route science teacher PCK develops as a result of alternate route teachers’ alternate route program learning experiences.

Research. More research is needed to tease out the particulars of how certification translates to teacher effectiveness. This study focused on which and how alternate route science teachers translated their learning from their alternate route program to classroom practice and which experiences facilitated their PCK development.

This qualitative case study generated an understanding of how professional learning in an alternate route program promoted the development of PCK in alternate route science teachers. Prior research has studied teacher self-efficacy in relation to PCK development (Duncan, 2013), specific professional development programs that foster PCK development (Spang, 2008), and PCK development of specific content areas in science (De Jong, van Driel, & Verloop, 2005; Park, Chen, & Jang, 2008; Park, Jang, Chen, & Jung, 2011, van Driel, et al. 2002). Other research has targeted the role of teaching experience in teacher effectiveness (Friedrichsen et al., 2009; Polikoff, 2013), as well as teacher college degree level on student performance (Goldhaber & Brewer, 1996; Grossman, 1990; Monk, 1994).

There is a debate in the research regarding the effectiveness of teachers based on their certification route (Goldhaber & Brewer, 2000). Research on one side indicates that students of science teachers who hold any type of certification (traditional, alternate, emergency) outperform students of teachers with no certification or those certified in a different subject but teaching science (Goldhaber & Brewer, 1999). Teach for America is the most researched alternate route program. Research found that student performance of science teachers in Teach for America were equivalent to or exceeded student performance by teachers from university-based teaching programs (Grossman & Loeb, 2010). Grossman and Loeb (2010) indicate that comparing teachers across teaching pathways (traditional versus alternate) yielded inconsistent evidence of effectiveness between these programs because both pathways have more and less effective teachers within them. As a result, research has indicated that there is more variation in teacher effectiveness across teachers who went through the same pathway than the average differences in teacher effectiveness between pathways (Grossman & Loeb, 2010). Due to the variability of teacher effectiveness within each program, research thus far, is inconclusive regarding which pathway produces more effective teachers.

Conflicting research indicates that teacher effectiveness of alternate route teachers is dependent upon the alternate route program, as well as the support the alternate route teacher receives from the district in which the teacher is hired (Humphrey & Wechsler, 2007; Humphrey, Wechsler, & Hough, 2008). Research has indicated that teachers prepared through the alternate route feel less prepared than those trained through the traditional route (Issacs et al., 2007). Alternate route programs have been found to be less effective at preparing and retaining recruits than university teacher education programs (Darling-Hammond, 2000). Alternatively, alternate route programs that require substantial pedagogical training, mentoring and evaluation similar to traditional route programs produce effective teachers (Wilson, Floden, & Ferrini-Mundy, 2001). Understanding which alternate route program learning experiences promoted PCK development of alternate route science teachers and therefore increased effectiveness of alternate route science teachers will advance the research understanding of how alternate route programs support alternate route teacher development.

Limitations of Study

Delimitations or boundaries of this qualitative instrumental case study were New Jersey's alternate route program. For instance, this study was limited in scope to the purposeful sample of participants in these alternate route programs as determined by the alternate route science teacher pool at the time of data collection. This study was also limited in scope based on accessibility of each district to conduct interviews and observations of participants.

Given the complexity of PCK development and the many variables that play a role in the development of the various components of PCK, it was impossible to eliminate every potential variable that could impact PCK development. Data collection and analysis served to sift through the data for generating assertions that were supported by evidence. In spite of these limitations to this study, the findings have implications for school leaders, potentially for alternate route teacher certification programs, and possibly for traditional teacher preparatory programs.

Additionally, as a researcher conducting an instrumental case study, interpretations are built upon making new meanings and making sense of observations and other data, to generate understanding of the experiences of alternate route science teachers (Stake, 1995). As the researcher serves as an instrument of data collection and analysis, this limitation has been addressed through varied methods of data collection to ensure data triangulation, as well as the characteristics of rigor in the study. Additionally, the reflexive journal will serve to help minimize bias.

Overview of Study

The following chapters describe this research study, findings, conclusions, and implications for supporting the success and development of alternate route science teachers. Chapter 2 reviews the literature surrounding teacher certification, teacher effectiveness and pedagogical content knowledge. Chapter 3 explains the methodology used in this research study. In Chapter 4, descriptions of the qualitative findings are presented, as well as findings regarding how and which alternate route program learning experiences alternate route science teachers perceived as promoting their PCK development. Chapter 4 also discusses how the findings achieve the goal of this study, describes the implications the findings have for supporting the development of PCK in alternate route science teachers, and identifies future research directions based upon the findings. Chapters 5 and 6 are manuscripts that will be submitted for publication to peer reviewed professional science education journals.

Chapter 2

Literature Review

Since the 1980s, there has been a call for improved science and mathematics education to ensure that the United States remains economically competitive (National Academies Press, 2007; National Center for Education Statistics, 2011; National Center for Education Statistics, 2012; National Commission on Excellence in Education, 1983; National Research Council, 2007; U.S. Department of Education, 1999; U.S. Department of Education, 2007). The manuscript, *A Nation at Risk* indicated the need for school reform to better the United States' international status of student performance in math and science (National Commission on Excellence in Education, 1983). Multiple educational reform efforts to promote greater student achievement have been enacted throughout the years including the No Child Left Behind (NCLB) legislation, professional development, and teacher evaluation (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Gusky, 2002; National Commission on Excellence in Education, 1983; New Jersey Department of Education, 2012). Most recent reform efforts in science education have led to the development of the Next Generation Science Standards (NGSS Lead States, 2013). In a discussion paper on identifying effective teachers, Gordon, Kane, and Staiger (2006) report that educational reform efforts that have focused on teacher credentials, increasing accountability, and reducing class sizes, thus far, have only had a marginal impact on the intended outcome of increased student achievement for all students. They assert that "the success of U.S. public education depends on the skills of the 3.1 million teachers in our classrooms… [because] without the right people standing in front of the classroom, school reform is a futile exercise" (Gordon, Kane, & Staiger, 2006, p. 5).

In response to the call for school reform, there has been focus on teacher effectiveness due to increasing awareness that "a national consensus is building that the quality of our nation's schools depends on the quality of our nation's teachers" (Feiman-Nemser, 2001, p. 103). This is evident in the generation of the NCLB act in 2002, as well as the New Jersey state mandates Achieve NJ and the 2012 TEACHNJ legislation for teacher evaluation based on student achievement (New Jersey Department of Education, 2012).

This national consensus regarding teacher effectiveness and evaluation of teachers based on student achievement comes as a result of years of research indicating that teacher effectiveness has a powerful influence on student achievement (Carey, 2004; Darling-Hammond, 1999; Darling-Hammond, 2010; Harris & Sass, 2011; Marzano, Pickering & Pollock, 2001; Stronge, 2010). In the late 1990s, Sanders and Rivers (1996) used a statistical approach known as the Tennessee Value-Added Assessment System (TVAAS) to determine the effectiveness of teachers based on student academic growth over time. TVAAS measured teacher effectiveness from the beginning of the year to the end of the year by comparing the actual growth in student learning to the expected growth in student learning using results from the Tennessee Comprehensive Assessment Program achievement test, the Tennessee state assessment for grades three to eight. Sanders and Rivers (1996) found that when low-achieving students were placed with effective teachers for three consecutive years, they demonstrated significant gains in achievement as compared to low-achieving students placed with ineffective teachers.

Sanders and Rivers (1996) reported “differences in student achievement of 50 percentile points were observed as a result of teacher sequence [effective vs. ineffective] after only three years” (Sanders & Rivers, 1996, p. 1). In addition, “the teacher effects are both additive and cumulative with little evidence of compensatory effects of more effective teachers in later grades” (Sanders & Rivers, 1996, p. 5). This means that students who are placed with sequential ineffective teachers do not make up the learning loss when eventually placed with an effective teacher. Hanushek (2002) determined that the learning difference for a student placed with an ineffective versus an effective teacher can translate into as much as one year’s additional learning for a student per each year that student is placed with an ineffective teacher. Identifying, supporting, and developing effective teachers are critical to attaining student achievement for all.

Babu and Mendro (2003) confirmed Sanders and Rivers’ (1996) findings in their three year longitudinal study of cohorts of students from the Dallas Independent School District as measured by the Texas Assessment of Academic Skills and Iowa Tests of Basic Skills. Rivkin, Hanushek, and Kain (2005) also corroborated Sanders and Rivers’ (1996) findings in their study of teacher influence on student achievement using data compiled for all public school students in Texas obtained from the University of Texas at Dallas Texas Schools Project. Studies by Barber and Mourshed (2007) focusing on understanding the reasons behind why the world’s best-performing school systems outperform other schools concluded that “evidence on teacher effectiveness suggest that students placed with high-performing teachers will progress three times as fast as those placed with low-performing teachers” (Barber & Mourshed, 2007, p. 13). In a paper discussing the research surrounding teacher effectiveness and the policy implications from this research, Berry, Daughtrey, and Wieder (2010) assert that "the teacher quality gap explains much of the student achievement gap" (Berry, Daughtrey, & Wieder, 2010, p. 1). Deeper understanding of how to support teachers in becoming effective teachers so that they can optimize student achievement would inform teacher preparation programs and school administrators on how to create or develop learning experiences that would promote teacher effectiveness and improve student achievement.

Numerous research studies demonstrate a strong relationship between teacher effectiveness and student achievement (Darling-Hammond, 1999; Darling-Hammond, 2000; Danielson, 2007; Tyler, Taylor, Kane, & Wooten, 2010; Marzano et al., 2001; Stronge, 2010; Tucker & Stronge, 2005). This chapter will review background literature on alternate route certification, how alternate route programs relate to teacher effectiveness, and their impact on student achievement in science. In addition, this chapter will review literature surrounding the qualities of effective instruction, the role of pedagogical content knowledge in teacher development, how pedagogical content knowledge relates to teacher effectiveness, and the impact of teacher pedagogical content knowledge on student achievement in science. This chapter will conclude with the rationale for this study.

Teacher Effectiveness

Most of the research on teacher effectiveness centers on student performance on standardized tests as an indicator of student achievement. Effective teachers are those teachers whose students demonstrate a high level of achievement on standardized assessments; primarily math and literacy scores (Babu & Mendro, 2003; Berry, 2010; Carey, 2004; Feiman-Neimser, 2001; Gordon et al., 2006; Harris & Sass, 2011; Rivkin, Hanushek, & Kain, 2005; Sanders & Rivers, 1996; Stronge, 2010). For example, Babu and Mendro (2003) studied teacher effectiveness by looking at student achievement in reading and math (grades three to eight) on the Texas Assessment of Academic Skills and Iowa Tests of Basic Skills. Harris and Sass (2011) used the Florida state assessment in math and reading for grades three through ten. Rivkin, Hanushek, and Kain (2005) determined teacher effectiveness by looking for large gains in student achievement for the students in reading and mathematics on the Texas Assessment of Academic Skills for grade three through seven. Tyler, Taylor, Kane, and Wooten (2010) measured teacher effectiveness using the Teacher Evaluation System from Cincinnati Public Schools which correlated student achievement growth on state mandated assessments in reading and mathematics for grades three through eight to performance on the Danielson Framework for Effective Teaching. Danielson (2007) describes four domains of effective teaching/teachers comprised of multiple components including planning and preparation, classroom environment, instruction, and professional responsibilities. Stronge's (2010) meta-analysis of research on teacher effectiveness indicated that factors that determined teacher effectiveness were verbal ability, knowledge of teaching and learning, certification standards, content knowledge, teaching experience, and meeting the needs of the students. Ripley (2010) also added that teacher effectiveness was increased by how teachers learn to analyze their practice and how they are supported by administration.

"Quality teaching fosters quality learning" (Glynn & Koballa, 2005, p. 82). In response to the call for educational reform, researchers studied the connection between teacher instructional practices, preparation, and student achievement. A variety of research studies and evidence in practice have demonstrated a strong relationship between teacher instruction and student learning (Danielson, 2007; Darling-Hammond, 2000; Hattie, 2009; Ferguson & Womack, 1993; Marzano et al., 2001; Monk, 1994; Stronge, 2007).

By analyzing data from the 1996 eighth grade National Assessment of Educational Progress (NAEP) math and science results, Wenglinsky (2000) studied the connection between teacher effectiveness and student achievement. In his study, Wenglinsky (2000) measured three aspects of teacher effectiveness; classroom practices, professional development to support classroom practices, and teacher inputs (education levels and years of experience). Wenglinsky (2000) found that for the 7,776 eighth graders who took the NAEP science assessment in 1996, "students whose teachers majored or minored in the subject they are teaching outperform their peers by about 40% of a grade level" (Wenglinsky, 2000, p. 7). Additionally, students whose teachers had received professional development in laboratory skills outperformed their peers by more than 40% of a grade level (Wenglinsky, 2000, p. 7). Furthermore, Wenglinsky's (2000) data indicated that of the three aspects of teacher effectiveness measured, the greatest role in promoting student achievement in science was classroom practices, followed by professional development that was specifically tailored to promote hands-on activities and higher-order thinking skills by the students. In a subsequent paper, Wenglinsky (2006/2007) extended this understanding to emphasize that professional development should focus on "the four key components of effective science teaching identified in the analysis of 1996 NAEP data – laboratory skills, hands-on learning, use of instructional technology, and frequent formative assessment" (Wenglinsky, 2006/2007, p. 29). Understanding which learning experiences from their alternate route program alternate route science teachers translate into classroom practice would inform the design of professional development to support the growth of alternate route science teachers.

In a policy brief on educational opportunity and alternate route certification, Darling-Hammond (2009) reported that "student achievement was most enhanced by having a fully certified teacher who had graduated from a university pre-service program, who had a strong academic background, and who had more than two years of teaching experience" (Darling-Hammond, 2009, pp. 7-8). In a report about the challenges that new middle school and high school teachers face from the National Comprehensive Center for Teacher Quality and Public Agenda, Rochkind, Ott, Immerwahr, Doble and Johnson (2007) reveal classroom management and pedagogical issues pose challenges for new teachers. Harris and Sass (2011) conducted a study of various types of education and training on teacher productivity to promote student achievement. Harris and Sass (2011) found that elementary and middle school teachers increased productivity to promote student achievement with years of teaching experience, which they attribute to learning by doing. Killion and Hirsch (2011), leaders of Learning Forward, a global advocacy organization for professional learning that results in student achievement, explain that effective teaching includes reflection on student assessment data, engaging in professional learning, and adapting instructional practice to meet the learning needs of their students. They also stress that effectiveness in teaching is a journey, as opposed to a destination.

To understand what makes an alternate route science teacher effective, it is important to understand how learning experiences support and develop alternate route teachers in science education, as well as how alternate route teachers receive this type of support and development. As such, it is essential for educational institutions in general, and administrators who support science teacher development, in particular, to better understand the factors that support alternate route science teachers in developing as teachers. This study explored with the intent to provide understanding of teacher development for alternate route teachers certified in science.

Certification Routes and Teacher Effectiveness

An alternate route teacher is a person who graduated from college with a degree other than education and transitioned to teaching in a classroom without formal training in education besides that required to obtain a provisional license to teach (Goldhaber & Brewer, 2000; Klagholz, 2000). In the literature, the authors use terms such as alternative routes or alternative route programs. In this paper, I will be using the national and New Jersey identification of alternate route program and alternate route teacher.

Alternate route programs were established by states "to improve the quality of the teaching force, as well as to alleviate projected shortages of teachers" (Feistritzer, 2009, p. 3). The National Center for Alternative Certification (2010) cited that "approximately one-third of new teachers being hired are coming through alternative routes to teacher certification" (National Center for Alternative Certification, 2010, Introduction, para. 1). According to New Jersey Department of Education data, alternate route science teachers comprised an average of 54% of the science teaching pool over the last ten years (R. Higgins, personal communication, September 3, 2014). According to Cochran-Smith and Power (2010), there has been a proliferation of multiple routes to teaching such that alternate route certification programs exist in all 50 states. Feistritzer (2009) asserts that the success of the alternate routes to teacher certification programs is due to the fact that they "are market-driven. They have been created all over the country to meet [the] demand for specific teachers in specific subject areas at specific grade levels in specific schools where there is a demand for teachers" (Feistritzer, 2009, p. 4).

Studies have shown varied facts impacting the low supply of science teachers in schools. One factor is the high attrition rate in teaching. For example, according to the Teacher Follow-up Survey (TFS) administered in the late 1980s, many teachers leave the profession early in their careers. Ingersoll (2006) used the TFS data to determine cumulative attrition of teachers and found that after five years, "between 40 and 50 percent of all beginning teachers have left teaching altogether" (Ingersoll, 2006, p. 203). Data from a 1994-1995 School and Staffing Survey indicated that the turnover rate for mathematics and science teachers is higher than for teachers in other fields (Ingersoll, 2006). Ingersoll's (2006) findings indicated that "the demand for new teachers is primarily due to teachers moving from or leaving their jobs at relatively high rates" (Ingersoll, 2006, p. 208). Ingersoll and Perda (2010) reported that a sufficient number of math and science teachers were being produced to meet the supply due to increased student enrollment and retirements and found that the math and science staffing problems were due to migration and preretirement attrition.

In addition, in areas of low supply, many teachers who are teaching science do not have the certification to teach science. For example, research indicates that in certain disciplines, there is an issue of supplying the required national demand. In a study of out-of-field teaching, Ingersoll (2003) quantified that in 1999-2000, 43 percent of public school life science classes and 59 percent of physical science classes in grades seven through twelve were taught by teachers who had not completed an academic major or minor in those disciplines (Ingersoll, 2003, p. 15). Birkeland and Peske (2004) reported that the shortage of teachers differs dramatically based on poverty level and geographic region due to differences in teacher attrition and migration.

Feistritzer (2009) reported that "in the sciences, including biology, geology, physics, and chemistry, 28 percent of alternate route teachers … teach science subjects" (Feistritzer, 2009, p. 11). Grossman and Loeb (2010) concur that alternate route programs are a response to specific labor market demands (such as special education, math, and science) and cite the New York City Teaching Fellows program, the Boston Teacher Residency program, Teach for America, and Milwaukee's Metropolitan Multicultural Teacher Education program as examples of such programs. Kee (2012) found that teachers who had majored in a STEM fields were 5.3 times more likely to enter education via an alternate route than a traditionally certified route (Kee, 2012, p. 30). Additionally, Kee (2012) found that a career changer was 4.6 times more likely than a non-career changer to pursue an alternate route rather than a traditional route to teaching (Kee, 2012, p. 30). Kee (2012) affirms that her results reveal alternate routes "disproportionately attract prospective teachers with backgrounds in high-need STEM subjects and those who had been working in other careers" (Kee, 2012, p.30).

Alternate route programs function under the assumption that deep knowledge of the content is the most critical component to being a successful teacher (Issacs et al., 2007). Provision for this assumption arose from studies such as Wenglinsky's (2002), which linked classroom practices to student achievement on the 1996 NAEP. Wenglinsky (2002) found that the more college-level science courses (or science pedagogy courses) that teachers had taken, the better their students performed on the 1996 NAEP science assessment (Wenglinsky, 2002, p. 4). Counter to this assumption is data that indicates alternate route teachers lack the pedagogical training to succeed which leads to poor retention rates, less job satisfaction, and decreased teaching effectiveness (Darling-Hammond, 1999; Darling-Hammond, 2000; Ferguson & Womack, 1993; Ingersoll, 2006; Monk, 1994). An explanation for this data is that "beginning science teachers often have difficulty relating various theories and methods taught in courses to what actually happens in their daily teaching practice" (Glynn & Koballa, 2005, p. 82). The assumption is that teachers make a difference in student achievement and teacher quality is related to certification status (Ludlow, 2011).

Furthermore, Feistritzer (2009) adds that:

> Alternate routes are based on the premise that post-baccalaureate candidates grounded in the subject matter they will teach, many with maturity and life experience, want to teach and can be transitioned into becoming effective teachers through on-the-job training programs designed to meet their educational and training needs in an efficient, cost-effective way. (Feistritzer, 2009, p. 4)

While some teacher educators argue that alternate route programs are generally inferior to traditional college-based teacher education programs (Darling-Hammond et al., 2009), other studies reveal that the pathways into teaching matter less than that of the quality of the training, especially the student teaching experiences, and how well these student teaching experiences connect to pedagogical coursework in the teaching program (Humphrey & Wechsler, 2007; Humphrey, Wechsler, & Hough, 2008). The 2009 findings of the U.S. Department of Education's Institute for Education Sciences study showed that no variable studied (e.g. student test scores, robustness checks, teacher practices, amount of coursework, education, teacher characteristics) resulted in a significant difference in teacher effectiveness of novice teachers regardless of the type of preparatory program (alternate route or traditional) (Constantine et al., 2009). Varied studies demonstrate that findings about teacher effectiveness as a result of teachers experiencing alternate route programs are inconclusive. Thus, there is a need to further research effectiveness of novice teachers graduating from alternate route programs.

Subsequent research by Ingersoll, Merrill, and May (2012) of teachers trained via the traditional teacher preparation revealed that teachers who receive less pedagogical training are more likely to leave the teaching profession. Greenlee and Brown (2009) reported that teachers having earned their teacher certification through alternate route programs are less prepared and leave teaching at higher rates than teachers prepared through traditional teacher preparation programs. Darling-Hammond (2010) attributes this attrition by teachers trained through alternate route programs to be a result of the fact that "many alternative programs skip student teaching altogether – giving their new recruits no opportunity to receive direct modeling from expert teachers" (Darling-Hammond, 2010, p. 40). In their review of the Constantine et al. (2009) study on classroom practices of teachers certified via traditional or alternate routes and their relationship to student achievement, Corcoran and Jennings (2009) reported that teachers trained through the alternate route who had received limited pedagogical training lowered their students' achievement. For example, in a New York City study on teacher effectiveness compared to certification status, Kane, Rockoff, and Staiger (2006) showed that these deleterious effects on student achievement were reduced when alternate route candidates completed their pedagogical training, gained teaching experience and met their licensure requirements.

As a result of differing findings across various studies, there is certainly a debate about the role certification plays in determining teacher effectiveness (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2006; Constantine et al., 2009; Corcoran & Jennings, 2009; Darling-Hammond et al. 2009; Humphrey & Wechsler, 2007; Humphrey, Wechsler, & Hough, 2008; Kane, Rockoff, & Staiger, 2006; Wilson, Floden, & Ferrini-Mundy, 2001). For example, a study conducted by the U.S. Department of Education's Institute for Education Sciences examined student achievement results and classroom practices of teachers certified via traditional and alternate routes who taught the same grade level (Constantine et al., 2009). The study found no statistically significant difference in the effectiveness of teachers certified via traditional and alternate routes on student achievement (Constantine et al., 2009).

Nonetheless, most studies relating certification status to teacher effectiveness and student achievement have focused on state assessment data using reading and math results (Boyd et al., 2006; Berry, Daughtrey, & Wieder, 2010; Constantine et al., 2009; Hanna & Gimbert, 2011; Harris & Sass, 2011; Wilson et al. 2001). Few studies have been conducted for science teachers. One study was conducted by Goldhaber and Brewer (2000) to determine if the type of certification a teacher held related to student performance on standardized assessments in mathematics and science. Using the *National Educational Longitudinal Study of 1988* they reviewed data for 2,524 students in science and 1,371 science teachers, of which 82% had standard certification (Goldhaber & Brewer, 2000, p. 133). They found that teachers who were not certified in their subject area had a negative impact on students' science test scores (Goldhaber & Brewer, 2000). Their results indicate that, in mathematics and science, teacher subject-specific knowledge is an important factor in determining tenth grade student achievement (Goldhaber & Brewer, 1996). They also found that students with science teachers who had a PhD are not found to have higher test scores than students with science teachers who did not have a PhD (Goldhaber & Brewer, 2000, p. 138).

Since one purpose of alternate route programs is to ensure that qualified teachers are placed in science classrooms, understanding the learning experiences of alternate route science teachers and how they translate these learning experiences into practice is paramount to supporting the success of alternate route science teachers in the classroom (Feistritzer, 2009). Consequently, it is important for educational institutions and administrators who support science teacher development to better understand how alternate route teachers certified in science develop as teachers.

One purpose of this study was to understand what learning experiences existed in an alternate route program for science teachers. Another purpose of this study was to explore how alternate route science teachers translated their alternate route program learning experiences into actionable practices in the classroom. Looking in depth at alternate route science teachers' alternate route program learning experiences generated an understanding of how these learning experiences facilitated pedagogical content knowledge development in novice teachers. In doing so, it is possible that the conclusions from this study could identify elements of alternate route programs that facilitate teacher effectiveness.

Pedagogical Content Knowledge

Shulman (1986) conceptualized and defined pedagogical content knowledge (PCK) as the knowledge of subject matter *for teaching* (Sulman, 1986, p. 9). Shulman (1986) stated that PCK was "the ways of representing and formulating the subject that make it comprehensible to others…the teacher must have at hand a veritable armamentarium of alternative forms of representation, some of which derive from research whereas others originate in the wisdom of practice" (Shulman, 1986, p. 9). PCK also includes teacher understanding of student preconceptions and misconceptions about the subject matter, as well as what makes the learning of specific topics easy or difficult (Shulman, 1986).

Grossman (1990) reorganized Shulman's model of teacher knowledge to emphasize the interaction between the various knowledge components; subject matter knowledge, pedagogical knowledge, knowledge of student's understanding of the subject matter, and added the component of curricular knowledge, which was a separate knowledge base in Shulman's model. Grossman (1990) defined PCK as "knowledge that is specific to teaching particular subject matters" (Grossman, 1990, p. 7). For their investigation on developing science teachers' PCK, van Driel, Verloop, and de Vos (1998) defined PCK as "teachers' interpretations and transformations of subject-matter-knowledge in the context of facilitating student learning" (van Driel, Verloop, & de Vos, 1998, p. 673). Van Driel et al. (1998) identified subject matter as a prerequisite for PCK and teaching experience as the major basis of PCK. Through their empirical study of the success of a workshop to enhance chemistry teachers' PCK of chemical equilibrium, van Driel et al. (1998) determined that teachers exhibit topic specificity for PCK and that "the value of PCK lies essentially in its relation with specific topics" (van Driel et al., 1998, p. 691). Through their continued research on the development of pre-service chemistry teachers' PCK, van Driel, de Jong, and de Vos (2002) determined that teachers' PCK growth was influenced mostly by their teaching experiences. They further contend that PCK denotes the teaching of particular topics, guides teachers' actions for promoting learning of the subject matter by students, and is developed through an integrative process embedded in classroom practice. In light of the fact that alternate route science teachers do not have formal teaching experiences prior to their placement in a classroom, their lack of teaching experience may or may not impede their effectiveness as teachers in the classroom. One purpose of this study was to identify alternate route program learning experiences that translated into instructional practices and another was to identify which alternate route program learning experiences facilitated the development of alternate route science teachers' PCK.

The results of the meta-analysis of research on the effects of teaching strategies on student achievement conducted by Schroeder, Scott, Tolson, Huang, and Lee (2007) indicated that the eight types of science teaching strategies (enhanced context strategies, collaborative learning strategies, questioning strategies, inquiry strategies, manipulation strategies, assessment strategies, instructional technology strategies, and enhanced material strategies) may be considered "*principles* for effective science teaching" (Schroeder, Scott, Tolson, Huang, & Lee, 2007, p. 1452, original emphasis). Additionally, to promote student achievement, PCK for teachers must include appropriate strategies to promote student acquisition of the learning outcomes in a lesson (Bransford, Brown, & Cocking, 1999; Shulman, 1986). Furthermore, Tal, Krajcik, and Blumenfeld

(2006) found that teacher PCK was essential to ensure successful implementation of inquiry learning curriculum materials and subsequent student achievement when targeting the effect of inquiry-oriented projects on student learning. Thus, promoting student achievement requires that teachers' PCK addresses effective principles of teaching and forms of teaching.

Moreover, Marzano, Pickering, and Pollock (2001) identified nine categories of instructional strategies that when used effectively, enhance student learning. In a policy brief on strengthening state licensure standards to advance teaching effectiveness, Berry (2010) asserts that teachers not only need to effectively demonstrate that they know how to teach key concepts in their curriculum, but also that they need to demonstrate effectiveness in doing so with students (otherwise known as PCK).

Friedrichsen et al. (2009) conducted a study to compare individuals with and without prior knowledge for teaching in an alternate route certification program designed to prepare post-baccalaureate students for certification in middle or secondary science teaching. Friedrichsen et al. (2009) found that teachers entering the alternate route certification program possessed limited PCK for teaching genetic variation, student learners, instruction, curriculum, and assessment. They also reported that the science teachers' orientation towards teaching and learning filters their understanding of student learners, selection of instructional strategies, curriculum, and assessment (Friedrichsen et al., 2009, p. 30). Their findings concurred with those of van Driel et al. (2002) that teaching experience matters in the development of science teacher PCK. Although alternate route science teachers have taken more courses in their content discipline in comparison to teachers who complete traditional teacher education programs, alternate route teachers often lack the instructional PCK required for optimal effectiveness in the classroom (Nakai & Turley, 2003). As such, identifying the learning experiences that promote PCK for alternate route science teachers can assist those who support alternate route science teachers in designing learning experiences to promote the development of alternate route science teachers' PCK, and in turn, promote student achievement.

Park and Oliver (2008) conducted a multiple case study of three experienced chemistry teachers at the same high school to re-examine the construct of PCK and to gain a better understanding of PCK. They identified that PCK development incorporates knowledge acquisition and knowledge use, such that teachers develop PCK through a dynamic relationship between knowledge acquisition, new applications of that knowledge, and reflection on the uses of that knowledge in practice. Park and Oliver (2008) found that teachers produce PCK through their own teaching experiences and the most powerful changes to their PCK are a result of these experiences in practice. This study corroborates van Driel et al.'s (2002) study regarding the importance of teaching practice to the development of PCK.

Park, Jang, Chen, and Jung (2011) conducted a quantitative study to test a hypothesis focused on whether or not teachers' PCK is necessary for reformed science teaching (inquiry-oriented teaching). Park et al. (2011) collected data on several high school biology teachers over two semesters using the Reformed Teaching Observation Protocol, RTOP (Piburn & Sawada, 2000) to measure the degree to which classrooms are aligned with reform efforts to be standards-based, inquiry-oriented, and student-centered. Additionally, Park et al. (2011) collected data using the PCK Rubric (Park, Chen, & Jang, 2008; Park, Jang, Chen, & Jung, 2011) to measure the level of a teacher's PCK based on observations and pre/post-observation interviews. Park et al.'s (2011) results indicated that content knowledge alone is not sufficient to advance PCK. This study aimed to elucidate the learning experiences that supported the development of alternate route science teachers' PCK in an effort to answer the call to "productively focus on developing teachers' PCK" (Park et al., 2011, p. 253).

Following up on van Driel et al.'s (1998) findings that prospective teachers do not explicitly demonstrate PCK, Davis (2003) analyzed one prospective science teacher's knowledge development as she developed a unit of instruction during an elementary science methods course. Findings revealed that the teacher was able to link science concepts to real-world experiences, but was unable to associate subject matter goals to PCK for certain concepts (such as light) to connect lessons for students. Davis' study (2003) focused on the teacher's instructional representations of subject matter and concluded that this component of PCK can be developed through teacher education for prospective teachers. Being that subject matter knowledge and teaching experience play a role in PCK development, understanding a prospective teacher's PCK readiness, how their existing PCK will be applied to their teaching, and which alternate route program learning experiences help to develop their PCK are critical for ensuring greater success of alternate route science teachers. In turn, greater success in the classroom may reduce attrition and promote greater alternate route science teacher retention.

Pedagogical content knowledge is unique to the teaching profession in that it is the knowledge that enables teachers to make specific subject matter accessible to specific populations of students. In a doctoral study, Spang (2008) studied the development of PCK by novice science teachers in a pre-service program and if and how they used PCK to support student learning. This pre-service program emphasized teacher development of how to make scientific inquiry accessible to all students (PCK). Spang (2008) found that students of teachers who graduated from this program showed higher learning gains on test scores than students of teachers who had not been in such a program (p. 158). Spang's (2008) doctoral study has implications that PCK can be promoted by engaging teachers in targeted learning experiences.

For science teachers to be effective in the classroom, they must have knowledge about science learners, curriculum, instructional strategies, and assessment through which they can transform their knowledge of science into effective teaching and subsequent learning by their students (Abell, Rogers, Hanuscin, Lee, & Gagnon, 2009). Research has shown that PCK is influenced by a teacher's orientation to science teaching as specific PCK are put into action (Abell, 2007; Grossman, 1990; Magnusson, Krajcik, & Borko, 1999). The assumption is that alternate route science teachers know their content well since they have extensive content preparation in science, but "they have not learned how to transform or translate that knowledge into meaningful units for instruction" (Veal & MaKinster, 1999, p. 14). Van Driel et al. (1998) affirmed that how teachers employ instructional strategies to promote student learning of specific subject matter is largely determined by their PCK, which can be advanced from their teaching practice, as well as learning experiences.

Polikoff (2013) focused a study on curricular alignment to the state standards as a measure of teachers' curricular knowledge, which is one component of PCK (Grossman, 1990; Shulman, 1986, 1987). Using the Surveys of Enacted Curriculum (SEC) in mathematics, ELA, and science (Porter, 2002), Polikoff (2013) determined that curricular alignment to the state standards increased with experience to a critical point between eight and eleven years of teaching and then decreased, with new teachers showing the weakest alignment. Polikoff (2013) surmised that more precise measures of teachers' educational experiences would show stronger results and suggested that future research probe the "specific ways that teacher education programs influence teacher understanding" (Polikoff, 2013, p. 223). This study generated a deeper understanding of how alternate route science teachers develop PCK by investigating which alternate route program learning experiences supported and promoted PCK growth.

In their seminal report on science teaching and learning, Duschl, Schweingruber, and Shouse (2007) discussed how important teachers' knowledge of instructional strategies were for teaching science to promote the learning of science (PCK) and they alluded to a dearth of research linking PCK to student achievement in science. While Hattie (2009) did not specifically address PCK, Hattie's synthesis of over 800 meta-analyses relating to student achievement concluded that it is those teachers using particular teaching methods, teachers having high expectations for all students, and teachers creating positive student–teacher relationships who are more likely to promote student achievement.

In a study that investigated how German math teachers' content knowledge and PCK affect student performance in secondary-level mathematics, Baumert et al. (2010) found that teachers' level of PCK determines the effectiveness of the "cognitive structure [the tasks chosen, instructional alignment to the curriculum, and student learning support] of mathematical learning opportunities" (Baumert et al., 2010, p. 166). They also found that a teacher's level of PCK was dependent on the type of training program attended.

They ascertained that PCK makes the greatest contribution to explaining student progress and that it can be acquired in structured learning environments (Baumert et al., 2010). Baumert el al. (2010) recommended that teacher research focus on how PCK can best be developed in both pre-service and in-service teachers. This study served to focus on the forms of alternate route program learning experiences that existed for alternate route science teachers, how alternate route science teachers translated these learning experiences into instructional practices, and what elements of these learning experiences promoted their PCK development.

Pedagogical content knowledge distinguishes science teachers from scientists and those who know science, based on how the knowledge is used and organized (to promote student learning versus application to their career). Pedagogical content knowledge differentiates novice teachers from expert teachers. As such, it is important to understand how to develop and support PCK in alternate route science teachers. Although Shulman introduced the concept of PCK in 1986, not much is identified from research about the manner of PCK development by beginning teachers and how to facilitate PCK development (De Jong, Van Driel, & Verloop, 2005). This study aimed to elucidate how alternate route science teachers translated their alternate route program learning experiences into instructional strategies, and developed their PCK to promote student attainment of their lesson targets. In doing so, this study engendered deeper understanding of how supporters of teachers can facilitate PCK; how teachers can be encouraged to think more critically about their practice and the reasons for their instructional strategies in light of student performance. Focusing on promoting PCK development in alternate route science teachers can, in turn, improve their effectiveness in the classroom and consequently, facilitate greater student achievement in science.

This study intended to develop an understanding of the elements that contribute to alternate route science teacher learning experiences which facilitated the development of their PCK. As the development of PCK has been indicative of greater teacher effectiveness (Friedrichsen et al., 2009; Spang, 2008; van Driel et al., 1998, 2002), findings from this study can inform support of the development and subsequent effectiveness of alternate route science teachers in the classroom.

A lack of success in science education and competitiveness has global and economic implications for the United States (Darling-Hammond, 2010). Based on the national and state focus on student performance in science, in conjunction with the role alternate route science teachers play in the teaching pool, it is important to understand how to support the development of alternate route science teachers so that they can effectively heed "the call for creating better prepared high school and college graduates to compete globally" (Breiner, Harkness, Johnson, & Koehler, 2012, p. 3). As such, it is important to understand how alternate route science teachers' alternate route program learning experiences translate into instructional practices, and how alternate route science teacher pedagogical content knowledge develops as a result of alternate route science teachers' alternate route program learning experiences.

Purpose of Study

Since one purpose of alternate route programs is to ensure that qualified teachers are placed in science classrooms, understanding the alternate route program learning experiences of alternate route science teachers and how they translate these learning experiences into practice is paramount to supporting the success of alternate route science teachers in the classroom (Feistritzer, 2009). This study sought to further understand the impact of alternate route programs on teacher effectiveness. As the development of pedagogical content knowledge (PCK) has been indicative of greater teacher effectiveness (Friedrichsen et al., 2009; Spang, 2008; van Driel, De Jong, & Verloop, 2002), the purpose of this study was to investigate how alternate route science teachers' alternate route program learning experiences informed a change in their classroom practice and facilitated the development of their pedagogical content knowledge. This research did not focus on the beliefs teachers had regarding the value of their alternate route experience. This study investigated the following research questions:

1. What aspects or learning experiences offered by an alternate route program translate into first year science teachers' classroom teaching?
2. In what way(s) do alternate route science teachers' learning experiences translate into instructional practices?
3. What elements contribute to alternate route science teachers' learning experiences that in effect, facilitate the development of their pedagogical content knowledge?

Chapter 3

Method

The purpose of this qualitative case study was to investigate how alternate route science teachers' learning experiences in their alternate route program are translated to their classroom practice and facilitated the development of their pedagogical content knowledge (PCK). This research generated an understanding of what learning experiences were available to alternate route science teachers in their alternate route preparation program. By using Shulman's (1986) theoretical framework on PCK and by looking through the lenses of adult learning theory and sensemaking theory, this research explored which participants' alternate route learning experiences translated into practice and how such experiences facilitated their PCK development. The setting was alternate route programs that enroll students seeking science teacher certification in New Jersey. Participants in this study were first year alternate route science teachers chosen through purposeful sampling. Data collection included semi-structured interviews, teacher-generated artifacts, and observations in an effort to understand how alternate route science teachers' learning experiences facilitated their pedagogical content knowledge development. As a result, this study investigated the following research questions:

1. What aspects or learning experiences offered by an alternate route program translate into first year science teachers' classroom teaching?
2. In what way(s) do alternate route science teachers' learning experiences translate into instructional practices?
3. What elements contribute to alternate route science teachers' learning experiences that in effect, facilitate the development of their pedagogical content knowledge?

Research Design

The design of this research was qualitative in nature so as to embrace an interpretive, naturalistic approach to the world (Denzin & Lincoln, 2005). This research was qualitative so as to facilitate exploration of a problem in order to generate a complex, detailed understanding of the issue (Creswell, 2007). As is the case for qualitative research, this research studied alternate route science teachers in their natural settings, in order to make sense of and interpret phenomena in terms of the meanings they brought to them (Denzin & Lincoln, 2005). Additionally, qualitative research was an appropriate design for study since it sought to "describe routine and problematic moments and meanings in individuals' lives" (Denzin & Lincoln, 2005, p. 4). A qualitative approach to this research also supported understanding an individual's point of view; understanding their lived and extended experiences through generating thick descriptions of these experiences (Denzin & Lincoln, 2005; Stake, 2010). The qualitative approach provided the means to study how these experiences provided meaning to participants and explanations of how such experiences emerged (Denzin & Lincoln, 2005; Miles & Huberman, 1994; Stake, 2010).

Strategy of Inquiry

This study used a qualitative instrumental case study design. As identified by Stake (1978), the target of a case study is to gain an "understanding, extension of experience, and increase in conviction in that which is known" (Stake, 1978, p. 6). Stake (2006) also explains that "case study was developed to study the experience of real cases operating in real situations" (Stake, 2006, p. 3). A case study was appropriate for this research because the goal of this research was to understand how alternate route science teachers' lived experiences (when they are in the alternate route program) and extended experiences (when they are teaching) translated into classroom instructional practices and facilitated development of their PCK. Case study helped generate understanding of the process of PCK development in alternate route science teachers.

"Cases of interest in education … are people and programs; … we seek to understand them for both their uniqueness and commonality" (Stake, 1995, p. 1). As defined by Stake (1995), "case study is the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (Stake, 1995, p. xi). In effect, the case study approach allowed for the understanding of PCK development through the lived and extended learning experiences of alternate route science teachers. The complexity of PCK development in alternate route science teachers was explored in order to understand which learning experiences (important circumstances) from the alternate route program facilitated PCK development. By understanding which alternate route science teacher alternate route program learning experiences translated into practice (important circumstances) a better understanding of how these learning experiences facilitated PCK development in alternate route science teachers was generated.

Through engaging in a qualitative case study, this research informed what alternate route program learning experiences alternate route science teachers found to be most useful in promoting their PCK development, as evidenced by how alternate route science teachers translated their alternate route program learning experiences into practice to promote student learning (Stake, 1995). In alignment with qualitative data analysis techniques described by Creswell (2007) and Stake (1995), categorical aggregation of the data was conducted to draw key meaning from the data, to search for patterns, and to develop assertions regarding which alternate route program learning experiences were perceived by alternate route science teachers to promote their PCK development.

Case study was chosen as the strategy of inquiry for this study in order to understand the complexity of alternate route science teacher PCK development; to understand how the alternate route program learning experiences of alternate route science teachers translated into a change in classroom practice, and the role these learning experiences played in the development of alternate route science teacher PCK. By using multiple sources of data to describe the learning experiences of alternate route science teachers, an in-depth picture of the case was presented for how their alternate route program learning experiences informed their PCK development. Key assumptions in this study were that alternate route science teachers made sense of their alternate route program learning experiences, articulated how their learning translated into practice, and identified how their learning promoted their PCK development (Loughran, Mulhall, & Berry, 2004; Magnuson et al., 1999; Mulhall, Berry, & Loughran, 2003; Park & Oliver, 2008). Since understanding the lived and extended learning experiences of alternate route science teachers was the focus of this research, case study was the appropriate methodology for documenting, interpreting, and communicating these experiences (Stake, 1995; Stake, 2010).

As is typical for case study research, data collection included multiple sources of information (Creswell, 2007; Stake, 1995; Yin, 2009). Using multiple sources of data provided the potential for convergence of the evidence (Yin, 2009). Multiple sources of data elucidated patterns among participants in how participants' lived and extended learning experiences translated into their classroom practices and informed their PCK development. The findings of this study identified what aspects of the alternate route program enhanced alternate route science teachers' PCK development.

Context, Participants, and Sampling Strategies

Setting. This study targeted New Jersey alternate route programs that enroll students seeking science teacher certification in New Jersey. The targeted alternate route programs were chosen from varied geographical regions within New Jersey to permit a potential sample pool of teachers who were representative of the general alternate route population of science teachers in New Jersey. Alternate route programs were chosen because the percentage of alternate route science teachers in the teaching pool over the last ten years ranged from 33% to 69% with the ten year average indicating that alternate route science teachers comprised 54% of the science teaching pool in New Jersey (R. Higgins, personal communication, September 3, 2014). In addition, since roughly 54% of the science teaching pool is comprised of teachers with no to minimal pedagogical training, the sites were also chosen to understand alternate route programs and their role in facilitating PCK development in alternate route science teachers. Access into the programs was provided through the solicitation of a variety of gatekeepers. For example, one targeted was the New Jersey Science Education Leadership Association (NJSELA). NJSELA is located primarily in northern and central New Jersey. Others included QUEST (which stands for Questioning Underlies Effective Science Teaching) and the CONsortium for New Explorations in Coherent Teacher Education (CONNECT-ED). QUEST and CONNECT-ED are inquiry-based summer institutes in science and math for

K-12 teachers; held by Princeton University and Rider University, respectively. The school districts who participate in these programs are located in central New Jersey in both urban and suburban settings and range in size regarding the numbers of teachers they employ and number of students they service. School districts were more likely to agree to access to their teachers if an administrator could vouch for this researcher, and the varied nature of the districts provided the potential for learning about alternate route science teacher PCK development across diverse school settings.

Participants. Sample participants were identified via correspondence with science supervisors who participate in New Jersey Science Education Leadership Association (NJSELA), as well as teachers and science supervisors of the member districts of QUEST and CONNECT-ED identifying first year alternate route science teachers in their districts. Sample participants were also identified via correspondence with Rowan University doctoral candidates working in the K-12 setting. A representative sample of alternate route science teachers was targeted for participation in this study. Additionally, alternate route program coordinators were also contacted to provide context of the alternate route programs.

Participants were identified through purposeful sampling (Patton, 1990; Patton, 2002). Purposeful sampling is the intentional selection of participants that can provide information-rich data for the purposes of illuminating the question(s) being studied (Patton, 1990). Purposeful sampling targeted participants that could best provide understanding of the problem and the research questions (Creswell, 2009). Purposeful sampling supported selecting information-rich cases that provided understanding of the phenomenon being studied (Coyne, 1997). Purposeful sampling was chosen to identify information-rich cases for in-depth study so as to "learn a great deal about issues of central importance to the purpose of the research" (Patton, 1990, p. 169). To understand how alternate route science teachers made sense of their alternate route program learning experiences, how these learning experiences translated to their classroom practice, and how these learning experiences promoted the development of their PCK, participants were chosen who created a picture of alternate route science teachers' sensemaking of their learning. The first criterion for selecting participants was to identify participants who could maximize information to learn, because the opportunity to learn is of primary importance for case study (Stake, 1995, pp. 4, 6; Patton, 2002, p. 233). Science teachers in an alternate route program and their first year of teaching allowed for study of how alternate route science teachers made sense of their pedagogical training from their alternate route program, in light of their prior science knowledge, and how these experiences facilitated their pedagogical content knowledge development. Identifying participants through purposeful sampling allowed for the assertions to be made regarding how alternate route science teachers made sense of their alternate route program learning, translated this learning into practice, and used this learning to develop their PCK.

Prior to choosing participants, a call for study participation was sent out to institutions across New Jersey that offered alternate route programs. Only two institutions responded that they would forward the opportunity to their students. Sample participants were identified through purposeful sampling via correspondence with district science supervisors. Six respondents replied to the call for participation. Of the six respondents, only three consented to participate in the study. Science teachers in an alternate route program and their first year of teaching allowed for study of how alternate route science teachers' alternate route program learning experiences translated to a change in classroom practice and facilitated their pedagogical content knowledge development.

Participants included one Caucasian female high school chemistry teacher in her early thirties (Dana), one Caucasian female high school biology teacher in her late twenties (Nancy), and one Caucasian male high school chemistry teacher in his mid-twenties (Henry) enrolled in two different institutions that provided alternate route programs in New Jersey. Pseudonyms were assigned to participants to maintain anonymity. The two female teacher-participants had several years of work experience in the field of science prior to transitioning to teaching through the alternate route. Both female teacher-participants held Bachelor's degrees in science (one in Biology and one in Chemistry). The male teacher-participant conducted undergraduate research in Chemistry prior to transitioning to teaching through the alternate route. All three teachers were in their first year of teaching and were enrolled in an alternate route program. Dana and Nancy attended the same alternate route (AR) program (AR1) through a university in northern New Jersey. Dana and Nancy taught in the same suburban high school in northern New Jersey. Dana taught two different levels of High School Chemistry and Nancy taught Biology and Environmental Science. Henry attended a different AR program (AR2) through a university in central New Jersey and taught two levels of High School Chemistry at a suburban high school in central New Jersey.

Both alternate route programs (AR1 and AR2) were hybrid programs that were identified as 75% online and 25% face-to-face. In the online portion of the classes, alternate route teachers engaged in online discussions of the readings and assignments. Face-to-face sessions were comprised of videos, group work, and presentations. AR1 divided their alternate route program into two stages, six courses, and fifteen credits. Stage I was a six week, sixty hour pre-service experience. Stage II was a ten month (September to June), 146 hour instructional period taken concurrently with the first year of teaching. Pedagogy specific courses, each a three credit course, were titled *Curriculum and Methods* and *Educational Assessment*. AR2 divided their alternate route program into three phases: Phase I being eighty hours of instruction, Phases II and III being sixty hours of instruction. While the phases of AR2 were not divided into courses, curriculum topics were identified. Pedagogy specific curriculum topics included *Instructional Strategies* and *Assessment*. At the time of data collection, all three participants were in the process of completing the last stage/phase of their alternate route program.

For qualitative research, sample size is justified by reaching data saturation (Saumure and Given, 2008). "Saturation is the point in data collection when no new or relevant information emerges," in this study, with respect to the case and its elements (Saumure and Given, 2008, p. 196). This researcher was confident that the sample size was large enough to ensure trustworthiness of the study when she sensed that she had seen and heard the data repeatedly and additional data would not add interpretive value to the case (Sandelowski, 2008).

Data Collection and Instrumentation

"Qualitative researchers seek data that represent personal experience in particular situations" (Stake, 2010, p.88). They do so because qualitative data are "a source of well-grounded, rich descriptions and explanations of processes in identifiable local contexts" (Miles and Huberman, 1994, p. 1). Data was collected using semi-structured interviews, teacher-generated artifacts, and observations (Stake, 1995; Yin, 2009). Teacher-generated artifacts included syllabi for courses, lesson plans, teacher worksheets, teacher notes/class agenda, student work, etc. Strategic and thorough data collection from participants was necessary to support the fine balance between obtaining thick description from each participant and obtaining comparative description from each participant (Stake, 1995).

Data collected was stored in a database according to data type and was organized according to research questions (Stake, 1995; Stake, 2010; Yin, 2009). Data that spoke to multiple research questions was duplicated and organized in more than one category (Miles and Huberman, 1994; Stake, 2010). In keeping with qualitative study being focused on the experiences of the individual participants, but to ensure confidentiality, pseudonyms were assigned to participants when reporting the data.

Semi-structured interviews. Qualitative interviewing serves to help the researcher see and experience the phenomenon being studied from the perspective and personal experience of the interviewee (Rubin & Rubin, 2012; Stake, 2010). The goal of interviewing is to understand the lived experiences of the interviewee, as well as the meaning the interviewee makes of those experiences (Stake, 2010). Semi-structured interviews are guided by a series of pre-determined open-ended main questions and follow-up probes in alignment with the research questions to help the researcher gain the perspective and insights of the participants regarding a specific topic of interest (Ayres, 2008; Rubin & Rubin, 2012; Stake, 2010). During semi-structured interviews, the researcher listens and responds to what is heard from the interviewees to gain the interviewees' point of view and so that the researcher can understand the experiences of the interviewees (Rubin & Rubin, 2012; Stake 2010). Semi-structured interviews were based on questions designed to elicit participant perspectives and experiences in order to understand how interviewee alternate route program learning experiences translated to the science classroom and facilitated their PCK development. Semi-structured interviews were conducted with identified participants.

Interview protocol. Semi-structured interview questions, in alignment with the research questions, were designed and used as the interview protocol (Stake, 2010). The interview protocol was used during the semi-structured interviews as a means to guide the interview and to document participant responses during the interview. The interview protocol was designed to ensure that the questions asked, helped to understand how alternate route science teachers, alternate route program learning experiences, translated into instructional practice and facilitated the development of their PCK (Rubin & Rubin, 2012). Interview questions gathered information regarding educational background, reasons for entering the teaching profession, beliefs about science teaching and science learning, what experiences were learned from the specific alternate route program, which learning experiences translated to a change in participants' classroom practice, and which learning experiences facilitated participants' PCK development (see Appendix C). All interviewees were assured confidentiality prior to the interview (Creswell, 2009). Audio recordings were made of participant interviews to compare with notes taken during the semi-structured interview using the interview protocol (Rubin & Rubin, 2012).

Semi-structured interviews lasted 45-60 minutes. An interview protocol was used to document participant responses and recorded interviews were transcribed ad verbatim. Transcribed interviews were member-checked by the participants to ensure accurate transcription of their ideas (Stake, 1995).

Prior to use, the semi-structured interview questions were piloted with former alternate route teachers at one central New Jersey high school. A full description of the pilot participants, procedure, and outcomes is located in Appendix J.

Teacher-generated artifacts. Teacher-generated artifacts complemented interview data because "'what people say' is often very different from 'what people do'" (Hodder, 1994, p. 395). Teacher-generated artifacts are durable and provided additional or new meaning to other data collected during this study (Hodder, 1994). Documents-in-use (teacher-generated artifacts in this study) provide information about the local context, as well as what people do and say (Rapley, 2007). Material culture (teacher-generated artifacts in this study) were used in conjunction with other data sources to coordinate and understand people's actions and interactions (Rapley, 2007).

Artifact protocol. Teacher-generated artifacts such as alternate route program descriptions, syllabi for alternate route courses, lesson plans, teacher worksheets, and teacher notes/class agenda were collected and analyzed for evidence of translation of alternate route program learning experiences into practice, what types of learning experiences supported PCK development in alternate route science teachers, and how these learning experiences facilitated PCK development in alternate route science teachers.

A teacher-generated artifacts summary form (see Appendix D) was created for each item since documents "typically need clarifying and summarizing" (Miles and Huberman, 1994, p. 54). The teacher-generated artifacts summary form was used to describe and record the significance of the teacher-generated artifact for the teacher and the relevance to translating alternate route science teachers' alternate route program learning experiences into practice.

Classroom observations. Observations are a means by which the researcher documents what she sees, hears, and feels of an event or activity for the purpose of recording the event or activity in an attempt to make sense of what is happening (Stake, 2010). Qualitative observations permit the researcher to record the behavior and activities of the participant in a systematic and purposeful way during an occurrence of interest to learn about a phenomenon of interest (Creswell, 2009; McKechnie, 2008; Rosen & Underwood, 2010). Naturalistic observations involve viewing and recording behaviors and activities such as classroom settings (Rosen & Underwood, 2010). By conducting classroom observations of alternate route science teachers, this researcher was able to record instances of translation of alternate route program learning experiences to classroom practice. Additionally, classroom observations permitted this research to record evidence of characteristics of participants' PCK during the observed lessons. Classroom observations provided data that added to and supported the data collected through interviews and teacher-generated artifacts.

Observation protocol. Classroom observations of alternate route science teachers teaching science were conducted to gather data on the translation of alternate route program learning experiences into classroom practice. Classroom observations were conducted with the prior knowledge of the alternate route science teacher and scheduled according to the alternate route science teacher's preference of time and class. One observation per teacher was conducted at the time and class of the alternate route science teacher's choosing with the intent that the teacher would showcase any translation of alternate route learning into practice. The observations were comprised of a pre-observation interview documenting the alternate route science teachers' intent for the lesson, their understanding of student misconceptions, how their instruction will serve to address those misconceptions, and how they will assess student understanding during the lesson (see Appendix E). An observation protocol, looking for indicators of inquiry, was used during the observation (see Appendix F) to gather data regarding the level of inquiry observed during the observation. Additionally, a PCK rubric (Park, Jang, Chen, & Jung, 2011) (see Appendix G) was used to gather data regarding the observed teacher's PCK during the observation, as well as during analysis of the observation protocol and field notes from the observation to identify evidence of PCK during the observation. The PCK rubric was generated in alignment with the five components of PCK (Park & Oliver, 2008). The five components of PCK are (1) orientations to science teaching, (2) knowledge of K-12 students' understanding in science, (3) knowledge of science curriculum, (4) knowledge of instructional strategies and representations for teaching science, and (5) knowledge of assessments of science learning (Park & Oliver, 2008). The PCK rubric "is an instrument to measure the level of a teacher's PCK based on observations of the teacher's teaching and pre/post-observation interviews" (Park et al., 2011, p. 250). The PCK rubric was designed and theoretically grounded in the pentagon model of PCK as described by Park and Oliver (2008, p. 266). The PCK rubric was used to compile data regarding the alternate route science teacher's level of PCK development as recorded during the pre/post-interviews and observation notes. A post-observation interview was conducted to document teacher perception of obtainment of the lesson target(s), teacher reflection of the lesson, and teacher perception of how their alternate route program learning experiences impacted classroom practice and student learning. The multi-faceted nature of the classroom observations provided data to inform in what way(s) alternate route science teachers' alternate route program learning experiences translated into instructional practices, as well as what elements of these learning experiences facilitated the development of their PCK. Field notes were created after each observation, documenting descriptive and analytic notes about what was seen and heard in the observations, as well as any first impression connections between the interview, observation, and teacher-generated artifacts.

Both the observation protocol and PCK Rubric were also piloted with former alternate route teachers. A full description of the pilot participants, procedure, and outcomes is located in Appendix J. In addition, the observation protocol was generated in 2008 by Mining Gems LLC and was used to collect data on inquiry based learning in Singapore (see Appendix F). Park, Chen and Jung (2011) documented the use of the PCK Rubric to evaluate a teacher's PCK in a holistic way.

Field notes. Field notes are a qualitative researcher's tool for recording in-depth descriptions of people, places, events, activities, and conversations, as well as a place for detailing reflections, hunches, reactions, and notes on patterns emerging from data during the research process (Brodsky, 2008; Glesne, 2006). Field notes turn sights, sounds, and objects recorded during observations and interviews into data that can then be analyzed and interpreted to learn more about the phenomenon being studied (Rossman and Rallis, 2003). By recording field notes as soon as possible after observations and interviews, this researcher was sure to document the experiences and her reactions to add to the meaning that the observations and interviews had for the study. Additionally, field notes provided documentation of the iterative research process and changes in thinking that occurred throughout the study.

Field notes protocol. Field notes were completed after conducting interviews and classroom observations. Field notes included both descriptive notes as well as analytic notes of interviews and observations. A field notes log (see Appendix H) was kept to document a description of events, as well as notes on emerging patterns and personal reactions of the researcher (Glesne, 2006). Field notes served as a means to record accurate information to visualize the setting, to note any behaviors of teachers during the interview, and to document interactions between teachers and students during the observations. Field notes helped to portray the context in which the interviews and observations took place (Glesne, 2006). Field notes were completed immediately after interviews and observations, when memories were fresh, so that they were richer and accurate (Glesne, 2006; Rossman & Rallis, 2003).

Reflexive journal. A reflexive journal provides data of the researcher's reflections as the research ensues (Borg, 2001; Janesick, 1999). Through reflective writing in a journal, the researcher refines her ideas, beliefs, and responses as the researcher becomes metacognitively aware of herself as a researcher (Borg, 2001; Janesick, 1999). Reflexive journal writing "captures and freezes thoughts" (Borg, 2001, p.172) which was vital to illuminating metacognitive processes throughout the research. Reflexive journal writing enabled this researcher to gain deeper understanding of the data, researcher bias, and the patterns emerging from the data throughout the research process.

Journal protocol. A reflexive journal was used to record researcher musings throughout the research process (Ahern, 1999; Borg, 2001; Janesick, 1999). The reflexive journal served as a means of continual reflection throughout the research process (Borg, 2001; Janesick, 1999). The reflexive journal enabled the researcher to put aside personal feelings and preconceptions, or at least make them visible during the research process (Ahern, 1999). The reflexive journal served to help this researcher enhance understanding of the role of the researcher and the thinking and reflection that took place during research (Janesick, 1999). Journal writing supported this researcher in reflexive focus on the research, which deepened understanding of the case and the role of researcher as an instrument of data collection in case study (Janesick, 1999; Stake, 1995).

Data Analysis

Data analysis techniques grounded in the same theoretical framework were used to analyze and interpret collected data for the ultimate aim of describing the case and generating assertions regarding how alternate route science teachers' lived and extended learning experiences promoted the development of their PCK. This section is organized according to analysis targeting each data source collected so as to illuminate how the data analysis techniques were conducive to the data collection tool.

Analysis of interviews. According to Stake (1995), there are four types of data analysis for case study research: categorical aggregation, direct interpretation, establishing patterns, and developing naturalistic generalizations. Categorical aggregation draws meaning across multiple instances of data (Creswell, 2007; Stake, 1995). Direct interpretation draws meaning across parts of a single instance of data (Stake, 1995). Patterns are similarities across multiple instances of data (Stake, 1995). Being that instrumental case study serves to understand phenomena or relationships, categorical aggregation of the data throughout the study provided understanding of the case (Stake, 1995). As such, categorical aggregation of interviews through coding was used to understand how alternate route science teachers translated their alternate route program learning experiences into practice, which learning experiences translated to their classroom practice, and which learning experiences facilitated alternate route science teacher PCK development. By engaging in categorical aggregation, patterns emerged, which informed how alternate route science teachers translated their learning experiences into practice and how their learning experiences assisted in the development of their PCK. Since the goal of case study research is to understand behavior, issues, and context of the case, "the search for meaning often is a search for patterns" (Stake, 1995, p. 78).

The interview notes and transcriptions were coded in multiple cycles using a priori, descriptive, and pattern coding. Coding is a systematic process of chunking the data into segments of text before bringing meaning to the data (Rossman & Rallis, 2003, p. 284). The first cycle of coding was conducted using a priori coding (Creswell, 2007; Miles & Huberman, 1994). A priori coding is a method of creating a list of codes that tie to the research questions and conceptual framework (Miles & Huberman, 1994). A priori codes were generated from PCK components and subcomponents identified (Park & Oliver, 2008) (see Appendix I).

The second cycle of coding was conducted using descriptive coding. Descriptive coding summarizes in a word or short phrase what is talked or written about (Miles & Huberman, 1994; Saldaña, 2009, p. 70). Descriptive coding served to illuminate concretely what was seen and heard during the interviews to identify lived experiences that translated to classroom instruction and facilitated PCK development. Descriptive coding is appropriate for use in studies with multiple data sources and served as a means of identifying patterns across data forms (Saldaña, 2009). Codes were generated by organizing the interviewee answers according to research questions and identifying repeating patterns in their answers.

Pattern coding is a way of grouping descriptive codes into a smaller number of groups or themes (Miles & Huberman, 1994; Saldaña, 2009, p. 152). Pattern coding was used to identify patterns regarding what forms of learning experiences existed for alternate route science teachers, in what way alternate route science teachers translated these learning experiences into instructional practices, and what elements contributed to alternate route science teacher PCK development. Codes were then clustered into themes to enable the merging of findings in order to generate assertions regarding how alternate route science teachers' learning experiences promoted the development of their PCK (Miles & Huberman, 1994; Stake, 2006; Yin, 2009). Coding was done by hand and data was stored in computer files.

Analysis of teacher-generated artifacts. Rapley (2007) cites that material culture (teacher-generated artifacts in this study) "can raise your awareness about how 'things'…are embedded in and intimately transform our actions and interactions" (Rapley, 2007, p. 89). Rapley (2007) affirms that material culture can provide insight into what people do and say. As such, teacher-generated artifacts were analyzed for evidence of which and how identified learning experiences translated to classroom documents that were used with students and/or parents. Additionally, teacher-generated artifacts were used to corroborate evidence generated from the other data sources (Yin, 2009). Teacher-generated artifacts and teacher-generated artifact summary forms were coded in alignment with the codes generated through analysis of the interviews, with respect to answering the research questions of how alternate route science teachers' learning experiences in their alternate route program translated into practice and facilitated their PCK development. Teacher-generated artifacts were analyzed to determine consistencies and inconsistencies between which learning experiences informed a change in alternate route science teacher classroom practice, and which learning experiences facilitated alternate route science teacher PCK development (Stake, 2006; Yin, 2009). While conducting analysis of the teacher-generated artifacts, focus was on what was said and what was not said in terms of how alternate route science teacher learning experiences were translated into classroom practice and how these learning experiences promoted their PCK development (Rapley, 2007). Asking the key questions: who, what, where, when, why, and how assisted in understanding the data found within the documents and promoted triangulation of this data with the other data sources.

Analysis of classroom observations. A priori coding, descriptive coding analysis, and the enumerative analysis approach as described by Park and Oliver (2008) were used to analyze classroom observations. Descriptive coding summarizes in a word or a phrase, the topic of a piece of qualitative data (Saldaña, 2009). Descriptive codes assisted this researcher in categorizing the data for subsequent pattern coding analysis. Since there were multiple data sources for the classroom observations, each data source was analyzed separately and findings were compared for similarities and differences per source. Additionally, the findings were analyzed for answers to the research questions. The specifics of this analysis for each protocol are described below.

Analysis of observation protocol. The categories and sub-categories of PCK were used as a pre-established set of codes for initial a priori coding of observation notes taken using The Indicators of Inquiry™ protocol (see Appendix I for these a priori codes). Additionally, descriptive codes were used to code the observation notes and the data was organized and categorized to identify patterns found between participants regarding their learning experiences in their alternate route program, which of these learning experiences were translated into classroom practice, and which of these learning experiences helped facilitate the development of their PCK.

Analysis of pre- and post-observation interview questions. Pre- and post-observation interviews were analyzed through a priori coding and descriptive coding, to clarify codes found in observation notes, as well as to triangulate data. The a priori codes and descriptive codes were used to classify the pre- and post-observation interview responses and a computer assisted qualitative data analysis software program was used to organize, categorize, and identify patterns regarding participant learning experiences in their alternate route program, which of these learning experiences were translated into classroom practice, and which of these learning experiences helped facilitate the development of their PCK.

Analysis of PCK Rubric. The PCK Rubric was analyzed for evidence of the alternate route science teacher's level of PCK development as recorded during the pre/post-interviews and observation notes. Given that the PCK rubric is a set of criteria for each component of PCK, the PCK rubric is a holistic means to analyze a teacher's PCK and identify a teacher's level of performance with respect to the development of their PCK (Park et al., 2011). The PCK rubric score was attained through analysis of and triangulation of interview and classroom observation data, including pre-observation and post-observation interview data. The PCK Rubric score informed which components of PCK were evident in the data in order to identify potential elements of learning experiences which facilitated the development of alternate route science teachers' PCK.

Analysis of field notes. Descriptive and analytic field notes were analyzed using the same a priori and descriptive codes used for analyzing the other data sources. Analytic noting or analytic memos of field notes were conducted throughout the research process to understand the patterns and themes that emerged during the research (Glesne, 2006; Marshall & Rossman, 2011). Field notes were analyzed using a priori coding, descriptive coding, and pattern coding to determine if the same codes identified in the interviews, observations, and teacher-generated artifacts emerged from the field notes. In addition, analytic memos of the observations were used to clarify descriptive codes found in observation notes.

Pattern coding was conducted with all data sources and the patterns that emerged from analysis of observations were compared to those that emerged from analysis of the interviews and teacher-generated artifacts. Pattern codes are "explanatory or inferential codes, ones that identify an emergent theme, configuration, or explanation" (Miles & Huberman, 1994, p. 69). Pattern coding served as the second round of coding to identify themes and patterns in the data. The pattern codes were then used to develop analytic statements that answered the research questions.

Data Triangulation

Since "data analysis is a systematic search for meaning," (Hatch, 2002, p. 148), data was triangulated to check the accuracy of the research findings (Creswell, 2009;

Stake, 1995). Data was triangulated through substantial incontestable thick description, methodological triangulation, and member checking triangulation (Creswell, 2007; Stake, 1995; Yin, 2009).

Incontestable thick description is rich, detailed description such that the reader comprehends the setting and details of the experience as if the reader had collected the data (Creswell, 2009; Stake, 1995). Incontestable thick description of participants' learned experiences and any translation of these learned experiences into practice allowed the reader to interpret the learning experiences in a similar fashion as this researcher (Stake, 1995). Analytic memos of observations and interviews supported the production of substantial incontestable description (Miles & Huberman, 1994; Stake, 1995).

Methodological triangulation in case study is the use of multiple approaches within the study so as to illuminate or nullify extraneous influences (Stake, 1995). Methodological triangulation of interviews, observations, and teacher-generated artifacts was used to help cognize which alternate route program learning experiences translated to a change in alternate science teachers' classroom practice, and which learning experiences facilitated alternate route science teacher PCK development (Stake, 1995; Stake, 2006; Yin, 2009). A comparison between field note and memoing data, interview data, observation data and teacher-generated artifacts was conducted to ensure methodological triangulation (Stake, 1995).

Member checking triangulation is the process of having participants read through transcripts of interviews, observations, memos, and findings to ensure that the data collected is accurate and palatable (Stake, 1995). By requesting that participants read through drafts of semi-structured interview transcripts, observation notes, memos, and findings, member checking triangulation ensured accurate documentation and representation of participants' lived and extended experiences (Stake, 1995). In addition, member checking confirmed that the data accurately captured and described what the teachers wanted to convey in their interviews (Stake, 1995).

Data interpretation of participant responses was viewed through the lenses of adult learning theory and sensemaking. These theories were used as lenses to deepen understanding of the case, in order to better understand and interpret the findings. Looking through the lens of adult learning theory helped deepen researcher understanding of how teachers learn, and subsequently deepened understanding of how elements of the alternate route science teacher's alternate route program learning experiences were translated into practice and how alternate route science teacher's alternate route program learning experiences facilitated the development of their PCK (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Feiman-Nemser, 2001). Sensemaking theory helped deepen understanding of how teachers made sense of their learning experiences in their alternate route program so as to deepen understanding of how their learning experiences were translated into practice and how their learning experiences facilitated their PCK development (Weick, 1995; Weick and Quinn, 1999, Weick, Sutcliffe, & Obstfeld, 2005; Weick, 2012).

Rigor

All of the strategies described above helped to ensure the rigor of this study in terms of credibility, transferability, dependability, and confirmability. To summarize, the rigor of this study was ensured during the research process through use of purposive sampling (Patton, 2002), thick description (Stake, 1995; Stake, 2006), member checks

(Stake, 1995), triangulation (Stake, 1995; Stake, 2006; Yin, 2009), and reflexivity through use of a reflexive journal (Rapley, 2007; Miles & Huberman, 1994; Stake, 1995; Stake, 2010).

Transferability. Purposive sampling to identify participants of the case helped to make sure that a picture of which alternate route program learning experiences informed a change in alternate route science teachers' classroom practice and which learning experiences facilitated their PCK development can be generated again (Patton, 2002). Thick description of the participants' lived and extended experiences provided experiential knowledge to readers so that they fully understand how each participant made sense of which learning experiences have informed a change in their classroom practice and which learning experiences facilitated their PCK development (Stake, 1995; Stake, 2006). Thick description promoted transferability of the lived experiences of alternate route teachers to the reader (Lincoln & Guba, 1985; Stake, 1995).

Credibility. Member checks of interview transcripts and memos created from coding and/or summarizing interviews were presented to participants to certify accurate reflection of their ideas (Stake, 1995). Triangulation of interviews, teacher-generated artifacts, and observations were used to help cognize how alternate route science teachers translated their alternate route program learning experiences into practice, which learning experiences informed a change in their classroom practice, and which learning experiences facilitated alternate route science teacher PCK development (Stake, 1995; Stake, 2006; Yin, 2009). Member checks and triangulation ensured credibility of data by verifying that the data collected and analyzed accurately reflected what was being expressed by the participants (Lincoln & Guba, 1995).

Dependability. Triangulation helped to preserve dependability of this study by ensuring that these same research questions can be answered with a different set of participants or with the same participants at a different time (Lincoln & Guba, 1985; Miles & Huberman, 1994; Stake, 1995; Stake, 2006; Yin, 2009).

Confirmability. Triangulation and reflexivity helped to safeguard confirmability of this research by making certain that researcher biases and/or influence over participants did not result in the study being tainted or compromised (Lincoln & Guba, 1985; Miles & Huberman, 1994; Rapley, 2007; Stake, 1995; Stake, 2006; Stake, 2010; Yin, 2009). Triangulation of interviews, teacher-generated artifacts, and observations were used to understand how alternate route science teachers translated learning into practice, which learning experiences informed a change in their classroom practice, and which learning experiences facilitated alternate route science teacher PCK development (Stake, 1995; Stake, 2006; Yin, 2009). The researcher reflexive journal documented reflexive thinking about data throughout the research process so that this researcher was sure to speak to bias or influence on the data collection process, as well as during data analysis and interpretation.

Ethical Considerations

Since this research is a case study involving research participants who are sharing their stories, ethical implications have to be considered. To that end, this research did not cause physical, emotional, or psychological harm to research participants (Rapley, 2007). The purpose, questions, and findings were transparent so that the research participants were fully informed regarding the nature and findings of this study. The study sought and gained Institutional Review Board (IRB) approval and contact with participants and/or data collection did not proceed prior to getting IRB approval.

Before beginning, confirmation was obtained so that participants knew that they were taking part in research, understood the focus of the research, and willingly consented to take part in the research. Additionally, participants were not pressured to have their interviews recorded. Unless subsequent permission from the participants is obtained to use the data for an additional purpose, the data collected was used and will be used for the purposes of this study only. As data was collected via interviews and observations, reporting of the findings was safeguarded to ensure that the participant's privacy and dignity was not compromised, as well as to guarantee confidentiality of the participants (Rapley, 2007). Participant identifiers were not present on any of the data and findings were reported in a fashion to ensure participant confidentiality. Data was stored securely in locked cabinets and password secured data files with personal identifying information redacted so as to maintain participant confidentiality.

To ensure that the research was conducted in an ethical manner, I remained aware that perceptions and values may influence interpretations (Stake, 2010) and thus worked to ensure they did not bias this research. By implementing reflexivity throughout data collection and analysis process, I looked for multiple perspectives to ensure that the findings reflected the perceptions of the participants; to make sure that the participants' learning experiences, their understandings of how these learning experiences informed classroom practice, as well as how these learning experiences promoted the development of their PCK were accurately portrayed (Stake, 2010).

Role of Researcher

In this study, I served as the major "instrument" of data collection and analysis. The interviews were somewhat structured, but the role of the researcher was still paramount as I posed follow-up and probing questions in order to elucidate participants' views and lived experiences. Similarly, several measures were undertaken to ensure the validity of data analysis, including member checking and iterative examination of data sets. Such measures, however, helped minimize, but in no way eliminated biases that were introduced as a result of the researcher's background and prior experiences. Thus, it is important to provide information about the researcher's background both in science and relevant work with science teachers who have participated in alternate route programs.

I hold a Bachelor's degree in Biology with a minor in Chemistry and a Master's degree in Pharmacology. In both undergraduate and graduate school, I completed quantitative research and wrote up my findings in theses. In my doctoral studies, I focused on developing an understanding of, and skills in, conducting qualitative research.

I am a former scientist who graduated from a graduate level teacher certification program after raising her children to school-age. The graduate level teacher certification program was the means for me to transition into teaching. I was a science teacher who taught grades six through twelve for five years and am currently a K-12 Science Supervisor for a public school district in central New Jersey. Having worked as a Science Supervisor in several different districts for the past eleven years, administrative and parental views on the potential success of alternate route teachers versus graduates of teacher preparation programs differs. I have had the opportunity to hire and provide mentoring and support for multiple alternate route science teachers over the years. Some have struggled, some have been unsuccessful as teachers, and some have flourished. As such, I began to question what factors in the learning experiences of alternate route science teachers led to their success. Throughout the research process, these musings shifted to engendering an understanding of how alternate route science teachers' alternate route program learning experiences informed a change in their classroom practice and facilitated the development of their PCK.

In my experience, alternate route science teachers lack classroom management skills, rarely understand student misconceptions, and gravitate towards teacher-centered activities. In my experience, alternate route science teachers struggle with how to create science lessons that make science easily accessible to students because they lack training and understanding on how knowledge is used and organized to promote student learning. Alternate route science teachers tend to have a weakly developed PCK initially. In spite of the fact that alternate route science teachers are transitioning from industry and/or research, and tout in their interviews that they want to show students connections to the real world and how scientists do science, they are rarely able to do so until later in their careers. In spite of the fact that alternate route science teachers conducted science before transitioning to teaching, inquiry-based learning is the exception, not the norm in their classrooms. These experiences helped me develop a deep understanding of the contexts within which educational programs such as alternate route can be developed and furthered in impacting effective teaching in science classrooms.

My background in science teaching and learning helped me develop an understanding of effective science instruction, as well as helped me to stay abreast of current reforms in science education. Additionally, in preparing for this study, I read quite extensively about the current debates related to alternate route programs. This latter preparation is crucial both in terms of conducting the interviews and analyzing the data, which required a deep understanding of the controversial issue at hand.

Realizing that the researcher approaches the world with a set of ideas, a framework (theory, ontology) that specifies a set of questions (epistemology), which are then examined (methodology, analysis) in specific ways is crucial to minimizing bias to the method and findings of the study (Denzin & Lincoln, 2005). As a former scientist, holding strong post-positivist views, objective and quantifiable data was the accepted norm for analyzing situations and problem-solving. As a doctoral candidate conducting a qualitative case study looking to construct meaning of alternate route science teachers' lived and extended learning experiences, a shift in thinking has occurred regarding the merits of quantitative and qualitative data and the differing roles and purposes of each based on the study being conducted. A reflexive journal was kept throughout the study in order to promote metacognition about the role of the researcher, as well as the personal feelings and preconceptions, in order to prevent bias from coloring analysis and interpretation of findings (Ahern, 1999; Borg, 2001; Janesick, 1999). The reflexive journal was used to help this researcher better understand the case and the research process. The reflexive journal helped this researcher to monitor her musings with regards to participant responses and emerging themes. The reflexive journal was used to document interpretations of the data and the challenges faced throughout the research process. The reflexive journal was used as a vehicle for reflecting on the research process to help this researcher grow

Gaining an understanding of what forms of learning experiences existed in an alternate route program for first year science teachers, in what way(s) alternate route science teachers' translated their learning experiences into instructional practices, and what possible elements contributed to alternate route science teachers' learning experiences that in effect, facilitated the development of their PCK will help me better support the success of alternate route science teacher hires. Additionally, findings from this study can inform district-offered professional development for alternate route science teachers.

Chapter 4

Findings

Findings reveal patterns among participant responses that emphasized the limited translation of learned pedagogical experiences from their alternate route programs into classroom instruction during their first year of teaching. In addition, findings show that participant alternate route program learned pedagogical experiences were not perceived to have attributed to participants' pedagogical content knowledge (PCK). Triangulation of data indicated that themes of *relevancy* and *reflection* emerged as being necessary for the participants to translate learned experiences from their alternate route programs into classroom practice and subsequently promote development of their pedagogical content knowledge. While not the focus of this case study, all participants indicated that in-district professional development experiences were perceived to have helped them to develop as teachers more so than their alternate route classes.

This chapter is organized based on the common themes and subthemes that emerged surrounding each research question and the elements of the case. This study sought to understand:

1. What aspects or learning experiences offered by an alternate route program translate into first year science teachers' classroom teaching?
2. In what way(s) do alternate route science teachers' learning experiences translate into instructional practices?
3. What elements contribute to alternate route science teachers' learning experiences that in effect, facilitate the development of their pedagogical content knowledge?

Program

In investigating the first research question, findings show that participants were provided courses in their alternate route program that focused on teaching pedagogy. Participants varied in their translation of their learned experiences into classroom practice. Even though data for this study was collected during the spring of the participants first year of teaching while taking their last set of courses in their alternate route programs, participants cited a limited number of learned experiences that were translated into their classroom practice.

Forms of learning experiences. Alternate route program description and syllabi collected from the participants, as well as website review of the programs, indicated that learning experiences addressing potential pedagogical practices for effective teaching were offered by both alternate route programs. Courses titled *Curriculum and Methods* and *Educational Assessment* in AR1 required assignments that claimed to engage students in creating lesson plans which incorporated direct and indirect instruction, creating a curriculum unit with a culminating assessment, presenting on existing research regarding issues facing the field of education such as instructional strategies, classroom management strategies, or assessment strategies, and participating in an online professional learning community seminar that required them to find primary research or a secondary document on new knowledge in teaching and learning and effective classroom practices. As specifically written in the program description as obtained in the course syllabi, courses titled *Assessment*, *Instructional Strategies*, and *Planning for Instruction* required students of the program to complete assignments that focused on "assessment for, of, and as learning," enhanced assessment, student use of feedback, growth mindset, peer collaboration and questioning, students with disabilities, and English Language Learners. Table 1 shows the varied course titles participants experienced including participant responses towards their learned experiences regarding their alternate route classes. Each participant highlighted different aspects of the learned experiences offered in their alternate route programs. Each participant emphasized different understandings of learned pedagogy.

Disproportionate experiences. Participants within the same alternate route program highlighted different elements of learned experiences, as well as different understandings from their alternate route program. For example, Dana and Nancy attended AR1 at the same time and were enrolled in the same alternate route courses, yet reported different understandings and potential translation of these learning experiences. Dana reported learning about diversity, literacy across and within the disciplines, special needs students, differentiated instruction, bullying, counseling services, adolescents, and psychology. Nancy reported learning about adolescents, child development, resources offered in schools, differences between the services offered at public and charter schools, as well as designing lesson plans and curriculum. The only common learning experience highlighted by both participants Dana and Nancy, who were enrolled in the same AR program, was learning about adolescents. Henry attended AR2 and reported learning about Student Growth Objectives, differences in philosophies, giving feedback to students, different teaching techniques (no specifics given), classroom management of students, and differentiated instruction. Dana and Henry attended different alternate route programs and both reported learning about differentiated instruction.

Table 1

Comparison of AR courses relative to each participant

Participant/ AR	AR Course Titles	Participant recounting of AR learned experiences
Dana/AR1	Classroom Management Curriculum and Methods Learning and Motivation Educational Assessment Reading and the School Curriculum	Some basic diversity, cultural diversity, there's a lot of talk about literacy in education; all types, Math, Science, even as well as the regular English literacy. That was a really big topic that was discussed. Some special needs, generic information, and differentiated instruction. Then recently we had to do class presentations where we all presented; there were mixed topics: some were bullying, counseling services, adolescents, psychology.
Nancy/AR 1	Classroom Management Curriculum and Methods Learning and Motivation Educational Assessment Reading and the School Curriculum	Currently, we are learning about adolescents and the way children develop; what kind of influences they undergo. We just finished looking at what kind of resources the school offers, in terms of guidance counselors, CST, substance abuse; a lot of alternate route teachers teach in charter schools and they have way different things than we have. We have online discussions about what the school offers, when we are allowed to send kids down, what type of student goes down there, that type of thing. They make us, we were taught, how they want us to design lesson plans and curriculums, which obviously is not how the district wants us to do it.
Henry/AR 2	Assessment Content Knowledge Ethical Practice Instructional Strategies Professional Development Learner Development Planning for Instruction Learning Environment Learning Differences Leadership and Collaboration	We talked about writing SGOs, differences in philosophies, giving feedback to students, different teaching techniques. How to handle certain situations if you have a student that's out of line, if you had to differentiate your lessons, you know if a kid is just having a bad day how do you handle it. If a kid just wants to put his head down and you know be there but not there. Just different scenarios and how to handle that.

Specific pedagogical approaches that targeted science instruction were not cited by participants or indicated in the alternate route program information; participants indicated that alternate route learning experiences were not subject specific and varied over the course of the year. As both AR programs enrolled first year teachers from all grade levels and content areas, alternate route learning experiences focused on topics applicable across grades levels and disciplines. Alternate route learning experiences included pedagogical training in differentiation, lesson and curriculum development, instructional strategies, assessment, and providing student feedback.

Learned Experiences

Discrepancies emerged among the three participants specifically on sensemaking of their learned experiences in order to apply them to their classroom practice. Field notes and participant responses to interview questions (both semi-structured and post-conference) revealed that much of the learned experiences in participants' respective alternate route programs did not translate to their instructional practice; rather, certain elements of those experiences did. Nonetheless, participants identified their learned experiences differently.

Translated learned experiences. Participants reported that the aspects of learned experiences they carried away from their programs did not translate into their teaching, albeit did provide certain helpful aspects. This varied among participants. For example, Dana indicated that knowing about differentiated instruction helped her to understand that different students have different needs. While Dana did not indicate that learning about differentiated instruction in her alternate route courses translated to differentiating her lessons, she indicated that learning about differentiated instruction helped her to chunk information for students. Nancy was enrolled in the same alternate route program at the same time as Dana, but did not identify any of the same learning experiences as Dana; in fact, Nancy stated that none of her alternate route learning experiences helped her in the classroom. A follow-up question to Nancy's response elicited that she felt she gained more from the learning experiences provided by an in-district induction program for new teachers than she did from her alternate route program learning experiences. Henry cited specific activities that he learned in a seminar session. Henry reported a specific instructional strategy (vocab tic-tac-toe) to emphasize student mastery of vocabulary as a learning experience helped him in the science classroom.

For participants to translate alternate route learning experiences into instructional practice, participants had to identify a learning experience that they felt connected to their teaching, conceptualize how to translate the learning experience into practice, and have the time to modify instruction to reveal the translation of their alternate route learning experiences into practice. Furthermore, for participants to translate an alternate route learning experience to their classroom practice, participants had to reflect on how their alternate route learning experiences applied to their classroom practice to make sense of how to translate their alternate route learning into classroom practice.

Dana indicated specifically that she had difficulty translating her alternate route learning to her teaching; she identified that she was translating pieces of her alternate route learning to certain parts of her classroom instruction. When Dana was asked in what way she felt that what she learned in her alternate route courses was being used in practice, Dana indicated:

> "Probably more pieces of it than like, real, real lessons. A lot of it is more experienced-based when I learn something and then if I go back and revisit something from alternate route, then I'll start making the connection – ohh, that's what they were talking about. Chunking is probably a really good example of that and differentiated instruction. I read about it, I wrote about it, I researched about it, but I never really understood how to implement it. When I did the lab and was actually able to chunk it successfully, then that's when I was able to make the connection."

Nancy and Henry indicated that they felt they were struggling to translate their alternate route learning experiences into their classroom practice. For instance, Nancy reiterated that she felt her alternate route learning was not being applied to her practice and elaborated that she felt the learning was not beneficial to high school as the learning was geared towards elementary education. Nancy's response revealed that she felt most of the alternate route learning did not pertain to her and therefore she was not seeing how to apply it to her classroom teaching. When Nancy was asked in what way she felt that what she learned in her alternate route courses was being used in practice, Nancy replied, "Really to be honest, nothing. I just don't feel that it's beneficial to any high school teacher not just specifically high school science. Again, they gear all for elementary education."

Henry indicated that his learning about providing individualized feedback to students as quickly as possible was being used in his teaching. However, he indicated that he found difficulty translating his alternate route learning experiences to his classroom practice. He noted:

> "There are times in alternate route where I think I struggle to kind of fit it in. Um, the one thing that probably sticks out is the feedback and just getting that individualized feedback to the kids as fast as you can just so they can kind of make the adjustments and you allow them to kind of grow into that learner."

Disconnected commensurable experiences. Participant responses which depict participants' views on why alternate route learning was not translated into classroom practice were culled from both the semi-structured interviews as well as the post-conference interviews. All participants indicated that they could not reconcile where to apply their learning to their practice, citing that the course assignments in their respective alternate route programs were not applicable to their practice in the classroom. All participants conveyed there was a disconnect between the theory they learned and what transpired in the reality of the classroom. Participants indicated that the assignments were seen more as exercises in compliance, as opposed to applicable to their current teaching responsibilities. For example, when asked what was it about her alternate route courses that inhibited her from translating learning from them into practice, Dana responded that:

> "I think it's the application piece that's missing honestly. We do a lot of reading on things, but there is only so much you can read. First year is very overwhelming as it is without having a zillion reading assignments. You write about what you read and we're expected to cite things, I feel it's more of a how to write a research paper sometimes, a formatting exercise than it is what is going to *actually* (teacher emphasis) be useful to me."

Furthermore, Nancy and Henry indicated that due to the diversity of grade levels, subject matter disciplines in their alternate route programs, and the fact that their alternate route courses and assignments were not directly addressing high school science teaching, they had difficulty applying their alternate route learning to their classroom practice. In her responses, Nancy indicated that, “So they kind of forced us to do it their way and learn it their way through the entire stage 1, but it wasn’t of any use to us because we all have our own formats.” She also elaborated that, “I think that they aren’t in touch with what’s going on in high schools; it doesn’t translate to the high school level.” She also added that “I think they just don’t gear anything toward what’s actually useful in the classroom, in terms of assignments.”

In his responses, Henry indicated that:

> “There are times in alternate route where I think I struggle to kind of fit it in. Um, just because there is such a mix of teachers. Um, and additionally just the different districts. Because we have people working in Urban District A and Urban District B and other people who are working in you know, Suburban District A and Suburban District B. So just, very, very diverse kind of melting pot of teaching.”

Teacher-generated artifacts that represented application of alternate route learning were also collected as a follow-up to participant interview responses. Dana and Henry provided one teacher-generated artifact apiece and both identified that these artifacts resulted from assignments in their alternate route program. Dana’s teacher-generated artifact was a lesson that she completed as an assignment for one of her alternate route courses. In response to whether or not she had any artifacts that demonstrated her application of her alternate route learning to her classroom, Dana indicated that her isotope lesson artifact represented application of her understanding of the use of direct versus indirect instruction. Alternate route learning about direct versus indirect instruction was not mentioned in Dana's answer to the interview question cited in Table 1.

Nancy stated that she did not have any teacher-generated artifacts that represented application of her alternate route learning but that she had teacher-generated artifacts representing application of her learning from the in-district induction program.

Henry's teacher-generated artifact was a Student Growth Objective lab that the students conducted. The lab was used for identifying student progress towards meeting Henry's evaluation goal. Henry indicated that this artifact demonstrated his application of his understanding of the role of inquiry to demonstrate mastery. Henry did cite learning about creating Student Growth Objectives in Table 1.

Instructional modifications. Responses by all participants to modifying instructional strategies as a result of their learned experiences in their respective alternate route programs indicated that all participants did not modify instructional strategies as a result of their learning from their alternate route courses. For example, Dana stated that her modification of instructional strategies was based on her experience teaching in the classroom and the responses of the students to her instruction rather than her alternate route learning. Dana indicated that as she gains more experience as a teacher and better understands teaching, she may realize the connection to her alternate route learning at a later time. When asked how she modified her instructional strategies as a result of her learning from her alternate route courses, Dana responded:

> "I really think mine is more by experience. I am modifying and then maybe I'll go back and realize what they were trying to communicate to me later. Yeah, I don't

> know that, I mean I've tried to some things, like with inquiry, like have the students try to discover things on their own, but actually I didn't find it so successful, especially in science, I find direct instruction a lot more successful than that."

Nancy stated that she had not made any modifications to her instructional strategies as a result of her alternate route learning. Nancy's prior cited response that she did not feel her alternate route learning was being used in practice because she did not feel it was beneficial to a high school teacher was her reasoning as to why she did not modify her instructional strategies as a result of her AR courses. When asked how she modified her instructional strategies as a result of her learning from her alternate route courses, Nancy responded, "I haven't."

Henry reported that he was unsure that he had made any modifications to his instructional strategies as a result of his alternate route learning; he had heard of differentiated instruction and techniques for reaching students from other sources and did not attribute that learning to his alternate route program. Henry attributed his learning about differentiated instruction and techniques for reaching students to prior courses he had taken in college. When asked how he modified his instructional strategies as a result of his learning from his alternate route courses, Henry responded:

> "I don't know that I did. Um, I mean we talked about differentiated instruction. We talked about all these kind of techniques to scaffold and reach every student but it's things I've heard before either in my previous classes or the 24 hour pre-service or just in speaking with the other teachers. So it's not to say that I didn't get anything from it, but I've already heard it… you know."

While the participants intentionally chose a lesson for observation which would showcase how they applied their alternate route learning to their classroom practice, participant responses indicated that they did not identify varied alternate route program learning experiences regarding application of their alternate route learning to their practice. Participants did not present specific examples in their classroom instruction or any explanations as to how they translated specific alternate route program learning experiences to their practice.

Participants were also asked how they had translated their alternate route program learning to their classroom practice during the post-observation conference. When asked during the post-observation conference how she saw her alternate route program learning experiences impacting her classroom practice and subsequently student learning, Dana indicated "Not much for this lesson; this was math and graphical based. Moving forward, literacy and word problems, learning to read problems. No need for differentiated instruction during this lesson."

In conjunction with the classroom observation, teacher-generated artifacts (handouts distributed to the students during the observation) were collected and how these artifacts represented translation of alternate route course learning into practice was discussed during the post-observation conference. Dana's first teacher-generated artifact collected during the observation was a two question quiz. Dana's second teacher-generated artifact collected during the observation was a lab to help students understand the targeted content. Dana indicated in her post-observation conference that her alternate route courses did not impact this lesson because she identified literacy and summarization strategies as the key understandings from her alternate route program. As the observed lesson was math and graphical based, she did not apply her alternate route learning about literacy and summarization strategies. Since she did not see the application of literacy and summarization strategies to this lesson, she did not translate her alternate route learning to the observed lesson.

When asked during the post-observation conference how she saw her alternate route program learning experiences impacting her classroom practice and subsequently student learning, Nancy indicated that she provided a variety of learning mediums during the lesson as a means to appeal to the variety of learners in the classroom by her response, “Appealing to every type of learner; that was the reason for use of the video, to reiterate information.”

Nancy’s first teacher-generated artifact collected during the observation was a think-pair-share activity for students to answer questions designed to review and elicit their understanding of the targeted content. Nancy’s second teacher-generated artifact collected during the observation was a lab provided to the students depicting the background information, objective, materials, procedure, tables for documenting a series of observations of pictures, data provided in the lab handout, as well as analysis and interpretation questions. Nancy indicated that her use of the think-pair-share, followed by a video which outlined the content to be addressed in the lab, followed by the lab, was her application of her alternate route learning about appeasing every type of learner (multiple learning styles in the classroom). Additionally, Nancy indicated that the think-pair-share activity at the beginning of her observed lesson and the cooperative group work students engaged in during the lab was an application of her alternate route learning. None of these learning experiences were cited by Nancy as demonstrating her application of her learning from her alternate route courses.

When Henry was asked during the post-observation conference how he saw his alternate route program learning experiences impacting his classroom practice and subsequently student learning, Henry responded:

> "Adjusting on the fly. Modifying lessons and assignments based on feedback from the students. Give me a 1-5 for understanding hand gestures (*as a means of formative assessment*). Since there is such a diversity of teachers in the program and it is mostly elementary teachers, it's like apples and oranges."

Henry's teacher-generated artifact collected during the observation was a series of problems on a worksheet. Henry indicated that this artifact represented application of his alternate route learning in that the problems were scaffolded for difficulty as the students progressed through the worksheet to engage all learners, as well as the fact that students were assigned to small groups based on their response to a targeted question designed to formatively assess their current understanding of this content (differentiation). Differentiation was cited in Table 1 as one of Henry's alternate route learning experiences.

Pedagogy

Findings under the theme of pedagogy centered on the alternate route program impact to participants' PCK development which included participant perceptions of PCK and the role PCK plays in science teaching. Additionally, findings regarding pedagogy focused on participants' definition of inquiry, their conception of science teaching, their understanding regarding the role of inquiry in science teaching and learning, and the level of inquiry observed during their classroom observation.

Program impact on PCK development. The majority of participant perceptions indicated no correlation between their alternate route course experiences and the development of their pedagogical content knowledge.

Table 2

Participant views of how AR learning experiences informed PCK

Participant	Participant Responses
Dana	They did talk about indirect and direct instruction so that would be something I think they kind of helped me with. Assessing students; there's been some good ideas on that I think that's floated around. The adolescent psychology, like kind of understanding where they are and that they're rebelling and how to kind of channel that positively. Those types of things have helped. But I do find a lot of the things in the alternate route class that they do recommend are really applicable for elementary settings or history and English settings and not so much science. So some of the tools they have in maps and worksheets are awesome but they would never, I could never figure out a way for them to apply here.
Nancy	Again, I don't think they have. Everything that I kind of know about it, I've learned through X [*the name of an in-district induction program for new teachers*].
Henry	I think that they've reinforced the ideas that I've kind of gathered so far. That this is kind of the background behind it. You know you can still formulate your own philosophy; you can still formulate the way you are going to run your classroom. But these are the people who kind of, you, know and these are the tactics, the ideas that have kind of led and paved the way so from there you know what do you resonate with? Are you into Danielson? Are you really going to kind of jump on that or do you do Bloom's taxonomy, are you going to Gardner's, you know and Pavlov. However, whoever you want to say, find what fits you and kind of turn that into your own. So, just definitely reinforcement of these ideas and kind of strategies.

For example, Table 2 demonstrates that Dana and Henry made connections to their alternate route learning experiences and teaching, but did not perceive that their alternate route courses directly facilitated the development of their PCK. Nancy indicated that she did not feel her alternate route program learning experiences informed her PCK. Nancy indicated that she felt her PCK development occurred as a result of an in-district induction program.

During the interviews and post-observation conferences, the participants indicated that their experiences in the classroom as a novice teacher proved most valuable to developing their PCK. Field notes also documented participant perceptions and statements that their classroom teaching experiences proved most valuable for developing their PCK. Dana and Henry were the most forthright in asserting that classroom teaching experience has played a larger role in developing their PCK and informing their classroom practice than their alternate route program learning experiences. Nancy attributed her growth in PCK to the in-district induction program for new teachers. Dana indicated that, "A lot of it is more experienced-based when I learn something and then if I go back and revisit something from alternate route, then I'll start making the connection – ohh, that's what they were talking about." Henry responded that, "I really think mine is more by experience I am modifying and then maybe I'll go back and realize what they were trying to communicate to me later." Nancy indicated that, "I didn't even know what that word meant before teaching. So everything that I kind of know about it, I've learned through X [*the name of an in-district induction program for new teachers*]." Table 1 indicated that both AR programs offered courses that would include lessons to facilitate pedagogical content knowledge development in teachers, but all three participants did not attribute their growth to any of those offerings. All participants indicated that they found that personal experiences in the classroom informed their PCK development more than their alternate route program lessons.

Table 3 shows participants' responses regarding the role pedagogical content knowledge plays in their teaching based on their understanding of conceptions of PCK.

Table 3

Alternate route science teacher understanding of the role of PCK in teaching

Participant	Participant Responses
Dana	In teaching science? Well, I think if you are talking about identifying where students can go wrong is something that would be key especially, we're learning the mole right now and just being able to rationalize that huge number of particles 6.02×10^{23} is really difficult for students, but it's something that I didn't know until I walked into it really. So, next year, I will know, hey, I know that I need to spend more time on this because this is something difficult for students to get. That's really more experienced-based in my opinion. I try to use the textbook as hints. The teacher's edition has common misconceptions and I try to make sure that I review those, but sometimes some of those questions that I get in the class, they are just nowhere close to what the textbook might say the common misconceptions are going to be.
Nancy	I think it's a way of structuring how you want the students to think about it and kind of get them to that higher level thinking. So we start with the basics: what, when, where, why, and we make them apply it, analyze it, come to a conclusion.
Henry	Well I think you need to know how your students learn and be able to relate to your students and understand that not one size fits all. Um, obviously you need to know the things you are teaching to the kids for… I mean… I think… I don't know how to say it. Obviously you need to know your stuff before you can go on and tell someone else, at the same time you need to know that maybe student A learns better visually where student B you need to hear it auditorily or student C needs to see it in actuality, like an experiment or something. So just understanding that even though science is pretty cut and dry, there are different ways to approach it for your students.

All three participants spoke to components of PCK regarding knowledge of students and student understanding of content. Dana spoke specifically about understanding where students encounter difficulty with abstract concepts based on classroom experiences, as well as being aware of and addressing common student misconceptions. Nancy spoke of scaffolding the learning to engage the students in higher level thinking. Henry spoke about knowing the content, as well as how the various students in his class learn to best address their learning needs.

Although all three participants defined PCK in very different ways (see Table 3), analysis of PCK rubric scores (see Appendix K for the participant rubric scoring and Table 4) indicated that participants' PCK fell primarily in the limited or basic understanding of PCK elements, with several elements for each participant falling within the proficient range. The PCK disaggregated level of performance rubric score for Dana was 1.9, for Nancy was 2.3, and for Henry was 2.4. The maximum disaggregated PCK rubric score is a four. As such, the scores indicate that Dana exhibited limited level of PCK, while Nancy and Henry exhibited a basic level of PCK during the scheduled classroom observation.

Table 4

PCK rubric scores for the participants

Participant	**Dana**	**Nancy**	**Henry**
Participant Raw Score	17/36	21/36	22/36
Participant Percentages	47%	58%	61%
Level of Performance	1.9	2.4	2.3

Emerged understandings of inquiry. Several semi-structured interview questions elicited participant understanding of inquiry and the role they perceived inquiry to play in science teaching and learning. The three participants had different definitions of inquiry, with Dana and Henry identifying some common elements in their definitions of inquiry. Dana identified inquiry as a process limited to problem statements as evident by her definition. She defined inquiry as a vague problem statement where the students would be provided with some background knowledge and would use resources to figure out the answer to the problem. Nancy also identified inquiry as a process but that in which one "uses knowledge." She defined inquiry as using knowledge to explore possibilities. Henry identified inquiry as a process more so limited to the clarification of steps in the scientific process. He explained inquiry as observing something, postulating questions about it, or having a problem to which you want to find a solution; the process of figuring out the answer.

When asked what the role of inquiry was in science teaching and learning, all participants indicated an aspect of discovery or figuring out. Dana described the role of inquiry in science teaching and learning as "providing students as opportunity to discover things themselves." She also added that "but students have difficulty making connections." Nancy described the role of inquiry in science teaching and learning as a means "to get them to know scientific method basics; to get them to question, make an observation and question, and then figure it out a way to solve that question." Henry stated that "it sets a really good foundation for finding answers and kind of setting the tone for the day. Start with a really good guiding questions and then start discovering."

Participant responses as to what teaching science looks like to them indicated that they all identified elements of inquiry in the classroom. Dana was the only participant who identified disconnect between her ideal concept of teaching science and her reality. Dana described her ideal for teaching science to include exploration, labs, and students figuring out and applying the science learned to the real world. Dana's description of her reality of science teaching was a curriculum, skills, and the teacher making real world connections after teaching the curriculum and skills. Dana stated, "if I could figure out how to teach them better and faster, I might have more time to discuss the real world." Nancy described teaching science as "everything hands-on," with examples such as "designing a physical representation, working on a lab, or practice actually doing something." Nancy also commented, "I always try to get them up." Henry described teaching science as "having the students engage in creating conversations and making observations. Then you break it down with information you can test." He elaborated that it should be "discussion and debate-driven," with the students "respectfully disagreeing."

In spite of definitions of inquiry describing exploration and figuring out, as well as an understanding that teaching via inquiry supports students in questioning and discovering science, the data from the Indicators of Inquiry™ (Mining Gems, 2008) classroom observation tool showed that all participants engaged the students in cooperative work with significant teacher guidance. In all three classroom observations, learners were engaged in questions provided by teacher, materials, or other source. Additionally, in Dana's lesson, learners were directed to collect certain data for the lab they conducted. For Nancy's observed lesson, learners were given data and told how to analyze. For Henry's observed lesson, data was neither collected nor given, as the task was for the students to complete a worksheet of mathematical problems. In both Nancy and Henry's observed lessons, learners were given possible connections, while in Dana's observed lesson, learners were given all the connections. In all three observed lessons, learners were not given the chance to communicate explanations. Dana's lesson targeted completion of a lab where the procedure was modeled, the data collected was identified by the teacher, and the evidence was explained by the teacher. Nancy's lesson targeted completion of a lab which served to verify content that had previously been taught. Henry's lesson involved the students in working in small groups to complete mathematical problems related to their study of chemistry.

Adult Learning and Sensemaking

By looking at the data through the lenses of adult learning theory and sensemaking theory, this study generated an understanding of what alternate route program learning experiences are available to alternate route science teachers, which and how alternate route program learning experiences were translated into classroom practice, as well as how alternate route science teacher alternate route program learning experiences facilitated their PCK development. Since learning is an active process of using new knowledge to build upon prior knowledge and involves a process of change when situated in meaningful and relevant contexts (Bransford et al., 1999), looking through the lens of adult learning theory generated an understanding of how alternate route science teachers' PCK developed, as evidenced by how alternate route science teachers translated their alternate route program learning experiences into classroom practice. Looking through the lens of adult learning theory also helped discern the particular alternate route program learning experiences that participants perceived to promote their PCK development.

The lens of sensemaking theory helped inform assertions regarding how alternate route science teachers made sense of their adult learning, in order to develop as teachers. In addition, sensemaking theory helped make visible the means by which alternate route science teachers' made sense of their learning in their alternate route programs, the connections alternate route science teachers made between their alternate route program learning experiences and their classroom practice, as well as how sensemaking assisted alternate route science teachers in the development of their PCK. Additionally, as a researcher conducting a case study, interpretations are built upon making new meanings and making sense of observations, to generate understanding of the experiences of alternate route science teachers (Stake, 1995).

Looking through the lenses of adult learning theory and sensemaking theory also helped identify patterns in the data and ultimately the emerging themes from the data. Adult learning theory and sensemaking theory helped generate deeper understanding of the case and the alternate route program learning experiences of the participant teachers which saw limited translation to classroom practice and which were perceived to have minimal impact on their PCK development.

Analysis of Findings

Two main themes emerged as a result of triangulation of findings of data sources. These were *relevancy* and *reflection*. Relevancy indicated how the participants saw the connection between their alternate route program learning and their classroom practice, how they made sense of their learning to translate and apply their alternate route program learning to their classroom practice, and how they saw their classroom practice changing as a result of learning in their alternate route program. Reflection indicated how the participants actively thought about their alternate route program learning and its pertinence to their classroom practice, how they carefully considered ways in which their alternate route program learning could positively impact their classroom instruction.

Relevancy. Relevancy was observed as being fundamental to alternate route science teachers' learning experiences being translated into classroom instruction. The participants indicated that finding relevancy between their alternate route learning experiences and classroom teaching responsibilities determined their ability to translate a learning experience from their alternate route program to classroom practice. Relevancy for the alternate route science teacher participants was determined by how meaningful their alternate route learning experience was to their classroom responsibilities and practice. Relevancy was attributed to the subthemes of time, relevance to teaching science, and relevance to teaching high school students. Participants lamented that the volume of readings and assignments, in conjunction with the workload for a first year teacher, limited their time to find relevancy between their alternate route program learning and their practice. Additionally, if participants perceived a disconnect between their alternate route program learned experiences and the teaching of either science or high school students, their learned experiences were not translated into classroom practice.

For example, Dana indicated that many of her learning experiences were more relevant for an English or history setting than a science setting. Because she did not find the learning experiences relevant to her science classroom, Dana did not see the application of this learning to her science classroom. Henry and Nancy noted that their alternate route programs were dominated by elementary alternate route teachers and rarely included experiences or examples connected to their secondary context.

Table 5

Participant responses that indicate relevancy is necessary for translating AR learning into practice

Participant	Participant Responses
Dana	But I do find a lot of the things in the alternate route class that they do recommend are really applicable for elementary settings or history and English settings and not so much science. So some of the tools they have in maps and worksheets are awesome but they would never, I could never figure out a way for them to apply here. I do real direct problems so a lot of the summarizing strategies would be more applicable to an English or history setting rather than a science setting. Some of the concept maps again, more applicable to English and history than science. A lot of it is based on literacy so they are focusing a lot on that. They're focusing a lot on papers. So, writing about adolescent psychology, making a list of resources that you can use to inform your science literacy, or literacy resources from the school. There's a lot of projects with that. We had to design a curriculum unit. I feel like it's a lot of projects and right now as a first year and as someone who wasn't traditionally trained, everything is so on the fly and experienced-based, you kind of feel like you're drowning with the amount of work that they give you.
Henry	We have elementary to high school. Um, so what works in a K-3 class might not work in high school. So, I have a lot of difficulty relating to kind of other people and how they go about it. Since there is such a diversity of teachers in the program and it is mostly elementary teachers, it's like apples and oranges.
Nancy	It's geared a lot toward middle school. Most of the teachers are middle school or elementary education so it's geared a lot towards 5-8; and it doesn't translate to the high school level. The majority of the people in our class are K-8 so they gear everything towards K-8, concentrating on 5-8. So you can't really translate that into high school, it's not the same stuff, we don't see the same problems, we don't go through the same steps, it's all different.

In effect, many of the alternate route program discussions, tasks, and learning experiences were perceived to lack relevance to their current classroom assignments. As evidenced by the interview and post-observation conference responses documented in Table 5, relevancy was deemed to be necessary for learning experiences to be translated into practice.

Moreover, all participants noted that their respective alternate route program advertised courses which provided pedagogical learning experiences that would lend themselves to application to the classroom. Findings indicate that translation of an alternate route learning experience to classroom practice was based on participants' ability to make sense of their learning experience and see its application to their teaching.

Furthermore, participants indicated that because they did not see the relevancy between their alternate route learning and their practice, they did not translate their learning from their alternate route courses to their classroom practice. Participants described this as mainly due to the fact that they were not asked to apply their learned experience in their alternate route courses to their specific learning context. For example, Dana indicated that she felt the application piece was missing from her alternate route courses, and rather that the assignments were reading and writing exercises to be completed for the program (see Table 6). Dana also indicated that the first year of teaching was overwhelming, which in turn, hindered her ability to translate her alternate route program learning experiences to her classroom practice.

Table 6

Participant responses as to why AR program learning was not translated into classroom practice

Probing questions	Participant responses
Interviewer: What do you think it is about the alternate route courses that sort of prevent you or don't help you translate learning into practice?	Dana: I think it's the application piece that's missing honestly. We do a lot of reading on things, but there is only so much you can read. First year is very overwhelming as it is without having a zillion reading assignments. You write about what you read and we're expected to cite things, I feel it's more of a how to write a research paper sometimes, a formatting exercise than it is what is going to *actually* (teacher emphasis) be useful to me. Whereas the X [*name of in-district PD]* workshops were more skill based; I'll model it for you and now you practice it.
Interviewer: Did you use that in the classroom?	Henry: Not yet. I'm trying to still implement it. I'm definitely looking to implement it in the fourth marking period. It was just kind of a crazy time with PARCC, SGOs, and we kind of… I was just trying to deal with all that. But I'm definitely interested in using it in my fourth marking period.
Interviewer: Why do you say that?	Nancy: It's geared a lot toward middle school. Most of the teachers are middle school or elementary education so it's geared a lot towards 5-8; and it doesn't translate to the high school level. The majority of the people in our class are K-8 so they gear everything towards K-8, concentrating on 5-8. So you can't really translate that into high school, it's not the same stuff, we don't see the same problems, we don't go through the same steps, it's all different.

Moreover, Henry attributed his lack of translation of alternate route experiences into classroom practice to time constraints from state testing and evaluation responsibilities. Both Dana and Henry mentioned that limited time to plan for translation was a factor for them in light of daily teaching responsibilities and alternate route program coursework. Furthermore, they both indicated that the daily responsibilities of teaching in the first year prohibited them from translating their learning to practice. However, Nancy did not mention time being a factor. Nancy attributed her inability to translate her alternate route program experiences to her classroom practice was due to her perception that the alternate route course assignments were geared towards elementary and middle school. Nancy claimed that her issues and problems in high school were very different from those in middle school.

Reflection. Reflection was observed to be important in alternate route science teachers' learning experiences promoting the development of their pedagogical content knowledge. Subthemes of time, compliance, connection to classroom teaching responsibilities emerged as explanations for the lack of reflective practice by participants. The theme of reflection emerged as participants indicated that they needed to have time to reflect on their teaching practice in order to develop their PCK. Participants had the opportunity to reflect during their alternate route courses as per program course descriptions, but when asked about reflective practice, participants indicated that they did not reflect. For instance, participant responses indicated that there was a lack of active reflection of the teaching practices in their alternate route learning experiences and in effect, participants felt that their alternate route learning experiences did not inform the development of their own PCK. As evidenced by participant responses in Table 7, active and ongoing reflection seems to be necessary in order to facilitate the development of alternate route science teachers' PCK.

Table 7

Responses speaking to the role of reflection in PCK development

Participant	Participant Responses
Dana	A lot of it is more experienced-based when I learn something and then if I go back and revisit something from alternate route, *then I'll start making the connection – ohh, that's what they were talking about* [emphasis added]. Chunking is probably a really good example of that and differentiated instruction. I read about it, I wrote about it, I researched about it, but I never really understood how to implement it. When I did the lab and was actually able to chunk it successfully, then *that's when I was able to make the connection* [emphasis added].
Henry	I really think mine is more by experience. *I am modifying and then maybe I'll go back and realize what they were trying to communicate to me later* [emphasis added]. Yeah, I don't know that, I mean I've tried to do some things, like with inquiry, like have the students try to discover things on their own, but it actually I didn't find it so successful, especially in science, I find direct instruction a lot more successful than that. *So it might be another one when one day when I find it* [emphasis added].

Dana and Henry both spoke about going back and revisiting or realizing connections to their alternate route learning experiences, in combination with their classroom experience, as being a means by which reflection promoted the development of their PCK.

Nancy did not speak about reflection in her responses. In fact, Nancy scored low on the rubric for reflection and her responses to interview and post-observation conference questions indicated that she did not perceive her alternate route learning experiences informed the development of her PCK.

Additionally, in response to an interview question regarding which alternate route program learning experiences helped her in the classroom and why, Dana noted, "maybe I'll go back and realize what they were trying to communicate to me later." In her response (see Table 6), Dana was invited in the alternate route program to write about what she reads and she saw that as an exercise in writing a research paper, as opposed to an opportunity to reflect and/or apply her learning. Moreover, comment such as “so I never really thought to keep the end goal in mind,” “I could never figure out a way for them to apply here,” and “I feel like it’s a lot of projects and right now as a first year and as someone who wasn’t traditionally trained, everything is on the fly and experienced-based. You kind of feel you’re drowning with the amount of work that they give you” show how Dana is invited in the alternate route program to reflect and apply her alternate route program learning but she struggled to do so. The last comment alludes to the lack of time Dana felt she had to reflect on her learning.

For Nancy, time emerged as a reason why she did not engage in reflection about her alternate route learning. This became apparent in her response to being able to take advantage of professional development opportunities where she stated, “I felt like I didn’t have the extra time, just between the alternate route and teaching. I didn’t have extra time.” Furthermore, comments such as “I have to learn their way and do their assignments their way then not apply any of that to the way I actually do things,” as well as “It’s a lot of what I would call, and my students would call, busy work. You know, read this article and tell me what you think. Or watch this documentary and tell me what you think” and “For the most part I find it not helpful … I do it because I have to” show how Nancy was invited in her alternate route program to reflect and apply her learning yet she did not realize the opportunity to reflect and apply.

Although Henry’s alternate route program description cited multiple reflection assignments, Henry’s responses spoke to specific activities that he was asked to complete for his alternate route program, not to being invited to reflect. These assignments did not encourage or afford Henry to opportunity to reflect on how his alternate route learning translated to his classroom teaching. For instance, a response to an interview question which focused on his alternate route program learning experiences that helped inform his PCK, Henry indicated that his learning to inform his PCK did not come from his alternate route program:

> "I think that they've reinforced the ideas that I've kind of gathered so far. That this is kind of the background behind it. *You know you can still formulate your own philosophy; you can still formulate the way you are going to run your classroom* [emphasis added]. But these are the people who kind of, you, know and these are the tactics, the ideas that have kind of led and paved the way so from there you know what do you resonate with? Are you into Danielson? Are you really going to kind of jump on that or do you do Bloom's taxonomy, are you going to Gardner's, you know and Pavlov. However, whoever you want to say, *find what fits you and kind of turn that into your own* [emphasis added]. So, just definitely reinforcement of these ideas and kind of strategies."

Time for reflection was another aspect that Henry alluded to:

> "I think it gets better with, you know, having a year under my belt lesson planning and kind of not knowing what it's going to be like in class. And I mean in the summer I'm literally going to take my entire lesson plans for all the units and kind of redo them and make the adjustments I need to make."

Based on participant understanding of the role of reflection in promoting their PCK, as well as the low PCK rubric scores, reflection emerged as a component necessary in the development of alternate route science teachers' PCK. Additionally, the lack of reflection being mentioned in the data is indicative of the role that reflection could play in promoting translation of alternate route learning to classroom practice, and subsequently, PCK development. The participants were not seeing the relevance of their assignments to their classroom practice, so they were not reflecting on their alternate route learning, even when asked to do so in their alternate route program. More research regarding the role of reflection in PCK development of first year alternate route teachers is warranted to tease out the complex role reflection plays in PCK development.

Discussion and Implications

In accordance with prior research, findings from this study demonstrate that there exist problems for first year alternate route science teachers specifically in their ability to translate pedagogical practices learned into their classroom practice (Darling-Hammond et al., 2001). Participants in this study had difficulty making sense of their alternate route program learning experiences and therefore indicated difficulty in translating those experiences into their classroom pedagogy. Participants specified that their alternate route learning experiences, especially discussions and assignments, had little to no direct correlation to their current practice in the classroom and therefore participants were unable to see the relevance of their alternate route learning experiences to their classroom practice. In effect, participants did not modify classroom instruction in accordance with their alternate route program learning. Furthermore, alternate route science teachers found difficulty in finding and making time for the reflection required to modify their instructional strategies as a result of engaging in their alternate route program learning experiences. Participants indicated that day to day responsibilities of teaching, in conjunction with transitioning to a new career (teaching), afforded them little to no time to reflect on their learning.

Emerging themes in translation. Participant responses regarding their alternate route program learning experiences generated themes regarding understanding of their students, the structure of and resources provided by schools, and pedagogy. Alternate route program learning experiences that include courses covering topics such as diversity, psychology, adolescent development, and addressing passive learners (identified as students not engaged in class) had the potential to help participants understand the growth and development of their students. Although participants cited engaging in these learning experiences to better understand their students, none of the participants spoke to how they used the information and learned experiences they were exposed to in their programs to approach or modify instruction. Participants did not articulate how they used these alternate route learning experiences in their classroom teaching. Alternate route program learning experiences regarding counseling services, child study team, substance abuse, support for students, had the potential to help participants provide support for students outside the classroom and also had the potential to be leverage for supporting academic growth of students. Knowledge of the resources a school offers to students and to whom to speak with if there was a concern about a student is necessary for a teacher to address the needs of the whole child. Again, when responding to questions involving translation of alternate route program learning experiences into classroom practice, none of the participants spoke to how they used their knowledge of school resources in their practice.

Alternate route program learning experiences that fell under the theme of pedagogy included differentiated instruction, disciplinary literacy, providing student feedback, designing lesson plans, and curriculum. While participants were exposed to courses which provided instruction on pedagogy for teaching, and while alternate route program learning experiences included pedagogical training in differentiation, lesson and curriculum development, instructional strategies, assessment, and providing student feedback, when questioned about which alternate route program learning experiences they translated into practice, participants indicated limited translation of their experiences; differentiated instruction, chunking, knowledge of special needs, and a specific vocabulary reinforcement instructional strategy.

Additionally, while participants had clear ideas regarding what teaching science looks like, as well as their own understandings of inquiry and the role inquiry plays in science teaching and learning, classroom observations indicated that the students were engaged in a substantially guided form of inquiry. Inquiry-based learning is considered best practice in science education (National Research Council, 2000). An emphasis on pedagogical reflection may help participants to identify this discrepancy and modify their instructional strategies to incorporate additional elements of inquiry.

As will be discussed in subsequent sections below, participants needed to see their alternate route learning as being directly relevant to their current teaching in order to make sense of the alternate route learning experiences and successfully translate it into classroom practice. Such findings are supported by prior literature such as Glynn and Koballa (2005) whose study on contextual teaching and learning indicated that "beginning science teachers often have difficulty relating various theories and methods taught in courses to what actually happens in their daily teaching practice" (p. 82).

Sensemaking and adult learning for translation and PCK development. As indicated above, participants had difficulty making sense of their assignments in relation to their current teaching. This emerged as a theme of relevancy. When participants did not see a connection or application of their alternate route program learning to their classroom practice then they did not translate their alternate route program learning experiences to their practice. Since the alternate route program cohorts contained elementary, middle school, and high school alternate route teachers, the high school teacher participants of this study had difficulty connecting and relating their alternate route discussions and assignments to their high school classroom setting.

Nancy struggled the most of the three participants with making sense of her alternate route program learning and subsequently, she could not cite any examples of translating her alternate route learning experiences into practice. She did not see the direct connection between her alternate route program learning assignments and her teaching; she perceived that most of the alternate route learning was geared towards elementary and middle school teachers.

Additionally, since none of their alternate route program learning experiences were specific to science instruction, all three teachers indicated that they struggled with reconciling the conversations and assignments. Much of these, they claimed were general in nature, were not district specific/aligned in format and content, or were what they perceived to be strategies effective for use in other disciplines. Literacy strategies and summarization strategies were not as easily translated if the participants could not see direct application of these strategies to their teaching. In their book on the adult learner, Knowles, Holton, and Swanson (2000) specify that adult learners need to see the relevancy of their learning in order to learn something. They further describe that adult learners learn most effectively when new learning is presented in real contexts and adult learners have the time to connect their new learning to prior understanding.

An additional component to successful sensemaking by the participants was having the time to reflect on their alternate route learning in order to make sense of it and apply the learning to their practice. This theme of reflection emerged from the data when looking at responses about the lack of connection between alternate route program learning and the science classroom, references to the lack of required application of their learning, as well as participant comments regarding the lack of time to process information due to the alternate route program course load and the workload of a first year teacher. Since alternate route science teachers do not have the teaching experiences from which to develop their ideas and skills for masterful teaching in the classroom, and since "contemporary learning theory recognizes the role that both experience and reflection play in the development of ideas and skills" (Darling-Hammond et al., 2001, p. 9), it is not surprising that alternate route teachers had difficulty making sense of their alternate route learning during their first year of teaching. As such, a key feature to alternate route science teacher sensemaking of their alternate route program learning experiences would be to provide intentional time for reflection of learned experiences when formulating new ideas for teaching. Doing so would thereby generate an understanding of "the ways in which people redeploy concepts" (Weick, 2012, p. 151) for the provider of the learning experiences, but most especially, metacognitively for the teacher. The need for intentionally engaging alternate route science teachers in reflection is also supported by Glynn and Koballa's (2005) findings that "beginning science teachers often have difficulty relating various theories and methods taught in courses to what actually happens in their daily teaching practice" (p. 82). A connection between sensemaking of learning promoted by reflection and PCK development is supported indirectly by Shannon's (2006) findings from his multi-method case study of four chemistry teachers' decision-making during the planning, teaching, and reflection stages of their practice to determine PCK's influence for the topic of chemical equilibrium. Shannon (2006) found that "teachers with less teaching experience displayed a model of PCK characterized by an underdeveloped and sometimes fragmented understanding of the topic as well as a fragile knowledge of student understanding" (p. 8). The concept of sensemaking offered a way of analyzing how teachers negotiated meaning (Allen and Penuel, 2015) from their alternate route program learning experiences, as well as how they made sense of how their alternate route learning informed their PCK development, as seen by translation of their alternate route program learning into classroom practice.

Participants were forthcoming regarding their feelings that they have translated a limited number of alternate route learning experiences to their classroom practice. Two of the three participants identified that they translated certain components of their alternate route learning to practice, providing teacher-generated artifacts to support their assertion. Based on participant responses, Dana and Henry felt that their alternate route learning experiences informed their approach to teaching, but that they did not necessarily directly modify instructional strategies as a result of their alternate route learning. The lack of modification of lessons as a result of their alternate route learning was attributed to either a lack of seeing the relevancy in terms of connection to their classroom practice or a lack of time to make modifications due to their alternate route course load and first year teacher workload.

For teachers, integrating theory into practice to modify their instruction and develop their PCK is an iterative process of evaluating specific classroom situations, student interactions with the content, and determining when and how to use their professional learning experiences to inform a change in practice (Darling-Hammond et al., 2001; van Driel, Verloop, & De Vos, 1998; van Driel, De Jong, & Verloop, 2002). In addition, adult learning is a cycle promoted through purposeful design of a learning environment that progresses through invitation to learn, or engagement, to experience, to *reflection* (emphasis added) and evaluation (Loucks-Horsley et al., 2010). The lack of reference to reflection in the data suggests that participants are missing a component of the adult learning cycle, a component that if not completed, can lead to diminished learning.

The participants in this study were in the beginning stages of this iterative process and would benefit from ongoing support for determining when and how to use their professional learning experiences to inform a change in practice. Moreover, promoting the adult learning cycle with purposeful intent to develop first year alternate route science teacher translation of alternate route learning to practice in an intentional, purposeful manner would support their PCK development.

Park and Oliver (2008) identified that PCK development incorporates knowledge acquisition and knowledge use, such that teachers develop PCK through a dynamic relationship between knowledge acquisition, new applications of that knowledge, and reflection on the uses of that knowledge in practice. Park and Oliver (2008) found that teachers produce PCK through their own teaching experiences and the most powerful changes to their PCK are a result of these experiences in practice. The responses from the participants in this study support and are supported by the findings of Park and Oliver (2008). Participant responses to interview questions that specifically asked teachers to explain the role of PCK in science teaching identified knowledge of students, knowledge of where students are in the learning process, as well as the teacher's role in structuring the classroom learning experience for the students to meet the students' learning needs. Dana focused on student misconceptions in her answer, Henry on multiple learning styles in the classroom, and Nancy on scaffolding instruction to promote higher order thinking by the students. Responses also indicated that participants felt their classroom experiences as teachers provided them great insight to developing their PCK than their alternate route learning. This finding is also supported by the work of van Driel, de Jong, and de Vos (2002) who determined that teachers' PCK growth was influenced mostly by their teaching experiences. As the participants did not engage in ongoing reflection regarding the uses of their alternate route learning in practice, reflection was a missing element in developing their PCK.

PCK rubric scores to measure PCK level during the observation and pre/post-interviews identified participants as falling within the limited or basic understanding of the PCK components of planning, implementation, and reflection. As the observation was scheduled and chosen by each participant for the purposes of demonstrating application of alternate route learning to the classroom, participants were forthcoming about the lack of application of their alternate route learning to the observed lesson. The lack of translation of their alternate route learning to their classroom practice can be explained by the fact that the participants did not see the relevance of their alternate route learning experiences towards their classroom teaching. Additionally, this lack of translation can be related to the lack of reflection about their alternate route learning and its application to their classroom practice. PCK rubric scores were in alignment with participant responses regarding the lack of PCK development as a result of alternate route learning. As the participants did not engage in intentional and purposeful reflection about how their alternate route learning could be applied to practice, it is not surprising that participants scored lower on the PCK rubric. One would expect new teachers to be in the initial stages of PCK development and without concerted reflection on the relationship between new knowledge and application to their teaching, classroom teaching experiences become the primary means for their PCK development.

These findings lead to an understanding that educational leaders can support the development of alternate route science teachers' PCK by providing a developmental continuum of professional learning experiences which promote sensemaking, reflection, and subsequently promote PCK development in these teachers (Huebner, 2009).

Triangulation of data sources indicated that because participants were not asked to apply their learning from their alternate route courses to their specific learning context, participants did not translate their alternate route learning to the classroom. Additionally, findings from this study indicated that first year alternate route science teachers did not perceive their alternate route learning experiences as informing the development of their PCK. Responses and themes that emerged from the data indicated that relevancy of their alternate route learning to their classroom practice, as well as reflection on teaching and learning was necessary for the development of their PCK. Findings from this study can inform the development and subsequent effectiveness of alternate route science teachers in the classroom (Friedrichsen et al., 2009; Spang, 2008; van Driel, De Jong, & Verloop, 2002). In effect, findings demonstrate implications for practice, policy and research.

Implications for practice. Historically, alternate route programs were one means to increase the number of science teachers in the teaching pool. In addition, it is important for educational institutions and administrators who support science teacher development to better understand how alternate route science teachers develop their pedagogy as teachers.

Further knowledge of what, which, and how alternate route science teachers' learning experiences translate into practice and foster the development of their PCK can inform which professional learning opportunities are offered or required to support their development as teachers. Identifying the learning experiences that are translated into practice for alternate route science teachers can assist those who support alternate route science teachers in designing learning experiences to promote the development of alternate route science teachers, and in turn, promote student achievement. By looking at which alternate route science teachers' learning experiences were translated into practice and in turn, facilitated their PCK development, it is possible that the conclusions from this study could identify elements of alternate route programs that facilitate teacher effectiveness.

As such, the findings from this study suggest that first year alternate route science teachers need to be exposed to more meaningful applications of learned experiences in their alternate route program to the actual practice. They need to make connections between the learning in their alternate route courses and their teaching responsibilities.

Additionally, they need to see their alternate route learning experiences as being relevant to teaching in order for translation into instructional practice to occur, and subsequently for PCK development. Participants saw relevancy in two different ways. On the one hand, relevancy was considered to be a direct connection between what their assignments required and what they were expected to do for their teaching responsibilities, or what their district required. On the other hand, relevancy was seen as the intent to apply their learning to their practice when they had the time. Additionally, participants needed time for reflection to see the connection between their alternate route leaning and their practice and time to actually revise and/or intentionally plan lessons in alignment with alternate route learning. Participants lamented that they could not find the time to apply their learning due to the demands of being a first year teacher and their lack of time.

Even though the participants were invited to reflect during interviews, post-observation conferences, and their alternate route program learning, the lack of participant reflection in the data indicates that supporters of alternate route science teachers need to provide alternate route science teachers strategic and intentional opportunities to reflect on their learning and the application of their learning to their classroom practice. Alternate route science teachers might well benefit from guided and modeled reflection during the alternate route program, as well as with their mentor in the school where they teach. The findings from this study are supported by Ripley (2010) who identified that teacher effectiveness was increased by how teachers learn to analyze their practice.

In accordance, participants in alternate route programs would benefit from intentional and implicit connections between learning and practice being made by alternate route program directors and/or instructors. Time for reflection and application of their learning to their practice could be infused into the alternate route program. Principals, supervisors, and mentors who support alternate route science teachers during their first year of teaching can help first year alternate route science teachers by engaging them in conversations regarding the application of their alternate route learning to practice, as well as by helping these teachers to make connections between their alternate route learning and their teaching responsibilities. In addition, first year teachers would benefit from specific PCK professional development and time to practice application of their new learning.

The findings from this study are supported by Leithwood and Jantzi's (2006) assertion that "there is a significant gulf between classroom practices that are 'changed' and practices that actually lead to greater pupil learning; the potency for leadership for increasing student learning hinges on the specific classroom practices that leaders stimulate, encourage and promote" (p. 223). For alternate route science teachers to apply their learning to their practice, alternate route programs and district leaders need to assist these new teachers in making sense of their alternate route learning, in seeing the relevance of the new learning to their practice, as well as its application to their instruction.

Furthermore, understanding how alternate route science teachers' alternate route program learning experiences inform their classroom practice and how these learning experiences help promote PCK development in alternate route science teachers will assist supervisors, principals, and districts in building the capacity of alternate route teachers to improve student learning in science. Understanding how to assist alternate route science teachers in developing into effective teachers is critical as it can positively impact student literacy.

Since PCK development serves as an indicator of teacher effectiveness, findings from this study can inform support of the development and subsequent effectiveness of alternate route science teachers in the classroom (Friedrichsen et al., 2009; Spang, 2008; van Driel et al., 1998, 2002). For instance, understanding alternate route science teacher PCK development and how their learning experiences in an alternate route program promote their PCK development will enable alternate route programs to better support the retention and success of teachers.

Implications for policy. Policy decisions regarding supporting alternate route science teachers during their first years of teaching can be aided by understanding how alternate science teachers' learning experiences in such programs translate into classroom practice (Feistritzer, 2009; Grossman & Loeb, 2010; Kee, 2012). By understanding which and how alternate route science teachers' learning experiences are translated into practice, this research can inform policy surrounding alternate route programs and the learning experiences they provide to support and promote alternate route teacher development and effectiveness. Likewise, findings from this research could inform policy surrounding the design of learning experiences for traditional route teacher preparation programs.

As such, findings from this study suggest that alternate route teachers would benefit from alternate route programs examining their programs for the course offerings and progression of courses offered in order to intentionally structure their program to be in alignment with the teaching responsibilities of the participants. By doing so, alternate route learning experiences may be seen as more applicable to alternate route science teachers' practice and will therefore more likely be translated into classroom practice. Additionally, alternate route programs would benefit from examining their courses for modeled, practiced, and intentional opportunities for reflection that results in actionable changes to the classroom practice of alternate route teachers.

Alternate route programs may better serve alternate route teachers by differentiating assignments to intentionally connect learning to practice for these new teachers. Alternate route programs may better serve alternate route teachers by engaging them in routine and practiced reflection. For example, the policy of engaging K-12 teachers at the same time for all of the alternate route courses may need to be re-evaluated, as this policy can hamper participants' ability to translate their alternate route learning into classroom practice. Additionally, extending the alternate route program to be a two year program and/or requiring additional clinical experiences before full time teaching could be considered to provide sustained support for alternate route teachers.

Since the alternate route program is the means by which alternate route science teachers attain their pedagogical knowledge for teaching, knowledge of the importance of relevancy, reflection, and application of new learning in order to translate this learning into practice adds to the literature surrounding science education pedagogy (Keeley, 2005; Loucks-Horsley et al., 2010; Mundry et al., 2010).

Implications for research. Further research can look into comparing elements within traditional and alternate route programs and how such elements can be modified to better address the development of teachers within such programs. Some future research questions that can be generated from such findings include: (a) What existing elements within traditional and alternate route programs help teachers translate their alternate route learning into practice? (b) What existing elements within traditional and alternate route programs help teachers develop certain aspects of their PCK? (c) In what ways do such elements differ in varied program contexts? (d) What existing policies help facilitate the translation of first year teachers' learning experiences into classroom practice? (e) What existing policies help in the growth and development of teacher PCK? (f) What forms of district-based professional development programs are most beneficial to novice alternate route teachers? (g) How does the amount of time for teacher reflection on their learning inform their PCK development? (h) How does a teacher's self-identity impede or foster his or her ability to reflect? It is anticipated that sharing the findings of this study can afford an opportunity for discussion regarding the effectiveness of such programs in light of the demand for quality science teachers.

More research is needed to tease out the particulars of how certification programs translate to teacher effectiveness. Conflicting research indicates that teacher effectiveness of alternate route teachers is dependent upon the alternate route program, as well as the support the alternate route teacher receives from the district in which the teacher is hired (Humphrey & Wechsler, 2007; Humphrey, Wechsler, & Hough, 2008). Alternate route programs have been found to be less effective at preparing and retaining recruits than university-based traditional teacher preparatory programs (Darling-Hammond, 2000). Alternatively, alternate route programs that require substantial pedagogical training, mentoring and evaluation similar to traditional university-based preparatory programs have been found to produce effective teachers (Wilson, Floden, & Ferrini-Mundy, 2001).

For science teachers to be effective in the classroom, they must have knowledge about science learners, curriculum, instructional strategies, and assessment through which they can transform their knowledge of science into effective teaching and subsequent learning by their students (Abell, Rogers, Hanuscin, Lee, & Gagnon, 2009). As relevancy played a key role in ensuring translation of learning experiences into classroom practice, ensuring novice teachers explicitly recognize how their learning applies to their practice needs to be a major component of designed professional learning experiences. More research is needed to elicit which alternate route learning experiences are deemed most relevant by alternate route science teachers and which learning experiences are translated into practice best promote student learning.

Park and Oliver (2008) found that teachers develop PCK through a dynamic relationship between knowledge acquisition, new applications of that knowledge, and *reflection* [emphasis added] on the uses of that knowledge in practice. Moreover, contemporary learning theory recognizes that reflection plays a role in the development of ideas and skills (Darling-Hammond et al., 2001). Beauchamp's (2015) review of the literature regarding reflection in teacher education identified that teacher educators have not provided clarity on the meaning of reflection and have not modeled the practice of reflection. Additionally, Beauchamp (2015) speaks to the importance of context for reflection being necessary for teacher education, which is in keeping with the findings of this study that teachers need to find relevancy to their learning in order to change their practice as a result of their learning. As such, more research is needed about ways to engage alternate route teachers in reflection regarding their alternate route learning and application to classroom practice. Additionally, more research is needed on how novice and alternate route teachers can benefit from ongoing, intentional reflection.

Conclusion

This qualitative case study researched lived and extended learned experiences of alternate route science teachers to understand how learned experiences from their alternate route program facilitated their PCK development. This study researched what learning experiences were offered by alternate route programs and which learned experiences from their alternate route program were translated into practice by first year alternate route science teachers.

Findings from this study indicate that participants did not exceed a basic level on the PCK rubric as a result of their alternate route learning. Findings reveal patterns among participant responses that a limited number of learned pedagogical experiences from their alternate route programs were translated into classroom instruction. Participants identified that they were unable to connect much of their coursework to their practice; unable to see the application of their alternate route learning to their practice. Participants identified that the demands of being a new teacher resulted in a lack of time to make changes to their practice in light of their alternate route program learning. Relevancy and reflection appeared to play a pivotal role in ensuring translation of teacher alternate route learning into practice, and in subsequently promoting PCK. Continued research is necessary to tease out the elements of alternate route programs, as well as traditional teacher preparation programs, which best promote teacher development.

Chapter 5

Exploring how alternate route science teachers' alternate route program learning experiences translated to classroom instruction

Abstract

The purpose of this qualitative case study was to understand how alternate route first year science teachers' learning experiences gained from their alternate route courses translated into their classroom instruction. Research questions targeted were (1) What aspects or learning experiences offered by an alternate route program translate into first year science teachers' classroom teaching? (2) In what way(s) do alternate route science teachers' learning experiences translate into instructional practice? Participants included three first year high school teachers from two alternate route program institutions. Data collection and analyses focused on semi-structured interviews, classroom observations, and teacher-generated artifacts of participant experiences as a result of their having attended alternate route programs. Findings reveal patterns among participant responses that emphasized the limited translation of learned pedagogical experiences from their alternate route programs into classroom instruction. Triangulation of data indicated the theme of relevancy as a key requirement for the participants to translate an alternate route program learned experience into classroom practice. Findings from the study inform understandings of how teacher participant learning experiences from alternate route programs translated to classroom practice.

Keywords: alternate route, teacher development, pedagogical content knowledge

Context of Study

A continued focus on effective professional learning by teachers is warranted because the “efforts to improve student achievement can succeed only by building capacity of teachers” (Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009, p. 7). Additionally, teacher quality has a powerful influence on student achievement (Leithwood, Louis, Anderson, & Wahlstrom, 2004; Wei, Darling-Hammond, & Adamson, 2010). In an attempt to address the fact that “little is known about the mechanisms through which professional development works to improve instruction” (Epstein, 2004, p. 157), this study attempts to further understand how first year alternate route science teachers’ alternate route program learning experiences are translated to classroom practice.

Alternate Route Teachers

Science and math teaching positions are difficult to retain with teachers who earn their teacher certification through the traditional methods due to high attrition and migration rates (Ingersoll & Perda, 2010). The problem of retention, coupled with problems of quality from traditional undergraduate teacher preparation programs in the 1980s, sparked the establishment of New Jersey’s alternate route program for teacher certification in 1984 (Klagholz, n.d.). Alternate route programs provide an expedient means for career-changers to enter the teaching profession. Alternate route teachers can receive from 24 hours to up to eight weeks of teaching preparation prior to beginning full-time teaching and that preparation continues part-time during their first year of employment as a teacher (Johnson, Birkeland, & Peske, 2005). In New Jersey, each alternate route certification applicant is required to: (1) obtain a baccalaureate degree with a major in the subject to be taught; (2) demonstrate subject competency by passing the relevant subject test of the Praxis II Exam

[2]; and (3) acquire and demonstrate teaching skill by completing a mentor-assisted, school-based internship (Klagholz, 2000; New Jersey Department of Education; State of New Jersey Department of Education, 2010). A certificate of eligibility is issued once an alternate route candidate meets all the requirements for the specific endorsement and the certificate of eligibility authorizes the candidate to seek and accept employment in a New Jersey public school. Once obtaining a certificate of eligibility and gaining full-time employment, the alternate route teacher receives support from a mentor teacher during the initial year of teaching while completing course work at an alternate route program training site. School administration monitors and evaluates the alternate route teacher's development and classroom performance, and at the end of the year, recommends whether or not the state should issue standard certification to the candidate (Klagholz, 2000; New Jersey Department of Education; State of New Jersey Department of Education, 2010).

The National Center for Alternative Certification (2010) cited that "approximately one-third of new teachers being hired are coming through alternative routes to teacher certification" (National Center for Alternative Certification, 2010, Introduction, para. 1). According to data provided by the New Jersey Department of Education, the percentage of alternate route science teachers over the last ten years ranged from 33% to 69% with the average indicating that alternate route science teachers comprised 54% of the science teaching pool over the last ten years (R. Higgins, personal communication, September 3,

[2] The Praxis II Exam measures subject-specific content knowledge, as well as general and specific teaching skills necessary for beginning teachers (Educational Testing Service, 2014).

2014). Moreover, little is noted in the literature about alternate route teachers' pedagogical success in the K-12 classroom.

Promoting Science Literacy

In light of United States students' performance scores on math and science international tests (e.g. PISA, TIMSS), compiled with the changes of state standards towards the use and implementation of new national standards in science, the Next Generation Science Standards, an understanding of science teachers' experiences in pedagogical preparation of teaching science is essential. Such experiences indirectly impact students' abilities to become scientifically literate and therefore to be able to acquire skills, content knowledge and processes essential for understanding, doing and achieving in science (American Association for the Advancement of Science, 1990; Michaels et al., 2008; National Research Council, 2007; Sadler, 2006).

Moreover, a lack of success in science education and competitiveness has global and economic implications for the United States (Darling-Hammond, 2010). Based on the national and state focus on student performance in science, in conjunction with the role alternate route science teachers play in the teaching pool, it is important to understand how to support the development of alternate route science teachers so that they can effectively heed "the call for creating better prepared high school and college graduates to compete globally" (Breiner, Harkness, Johnson, & Koehler, 2012, p. 3). In order to do so, it is critical to understand how alternate route science teachers' learning experiences in their alternate route program translate into instructional practices.

The purpose of this study was to understand how participant teachers' learning experiences in an alternate route program translated to pedagogical choices in the classrooms they teach. To augment this purpose, the study also focused on teacher participants' practices in the classroom. Moreover, the study targeted the exposure to pedagogical practices that alternate route teachers experience in their preparation programs. It is anticipated that an understanding of how alternate route teachers are exposed to pedagogical learning experiences will help identify features that may lead to supporting and developing alternate route teachers in science education.

Theoretical Framework

This study relied on varied theoretical frameworks in order to gain a holistic understanding of the experiences to which participants were exposed. To this end, methodology and data analysis relied on the use of adult learning theory (Loucks-Horsely et al., 2010) and sensemaking theory (Weick, Sutcliffe, & Obstfeld, 2005, Weick, 2012), in conjunction with Shulman's (1986) theoretical framework on pedagogical content knowledge (PCK). In addition, alternate route science teachers' espoused theories and theories-in-action (Argyris & Schön, 1974) were explored to elucidate how changes in beliefs, as a result of professional learning, translated to changes in practice for alternate route science teachers.

Adult Learning Theory

Alternate route science teachers rarely, if at all, have any pedagogical training prior to entering a classroom. In order to develop masterful teaching in the classroom, it is essential to develop the skills and processes reflective of best teaching practices to address student learner needs. Addressing such needs, requires professional learning experiences that address pedagogical practices which are rarely experienced by alternate route teachers (Darling-Hammond, Austin, Orcutt, & Rosso, 2001; Davis, 2003; Spang, 2008). Thus, a key feature to alternate route science teacher development would be professional learning experiences from which they draw when formulating new strategies in teaching. Hence, it was essential to understand the epistemology of adult learning to grasp an understanding of alternate route teachers' reflection of their own learning experiences.

This study identifies learning as an active process of using new knowledge to build on prior knowledge. This emanates from interactions with ideas and phenomena, and involves a process of change when situated in meaningful and relevant contexts (Bransford et al., 1999). Adult learning therefore, is a cycle promoted through purposeful design of a learning environment that progresses through invitation to learn, or engagement, to experience, to reflection, and evaluation (Loucks-Horsley et al., 2010).

This study looked through the lens of adult learning to discern the process by which first year science teachers interacted with the ideas and learning experiences in their alternate route program and translated their new understandings to their classroom practice. This study looked through the lens of adult learning to generate an understanding of first year science teachers' adult learning in an attempt to inform which and how alternate route science teachers translated their alternate route program learning experiences into classroom practice.

Sensemaking Theory

The study also used sensemaking theory to address how alternate route science teachers made sense of alternate route program learning experiences in order to translate these experiences into classroom practice. Weick, Sutcliffe, and Obstfeld (2005) describe sensemaking as a process of socially constructing plausible meanings that rationalize action when discrepant cues interrupt a person's ongoing activity. Sensemaking theory helped inform assertions regarding how alternate route science teachers made sense of their adult, professional learning, in order to translate that learning into practice and develop as teachers. Understanding how such learned experiences are translated into classroom practice can help support the growth of alternate route science teachers by providing a developmental continuum of professional learning experiences which promote sensemaking, and subsequently promote change in practice for these teachers (Huebner, 2009).

Method

This qualitative study followed a case study design (Stake, 1995). A case study design was chosen for the study because the goal of the research was to understand how alternate route science teachers' lived experiences (when they are in the alternate route program) and extended experiences (when they are teaching) translated into practice. Case study design helped to generate understanding of the process of development by allowing the researcher to understand the components that could be viable factors impacting the case (Stake, 1995). In this study, the case being the lived experiences of the first year alternate route science teachers. The theoretical framework noted informed the kinds of tools being used to collect and analyze the data.

Setting and Participants

Participants included two female high school science teachers and one male high school science teacher enrolled in two different institutions that provided alternate route programs in New Jersey. In keeping with qualitative study being focused on the experiences of the individual participants, but to ensure confidentiality, pseudonyms were assigned to participants when reporting the data.

The two female teacher-participants (Dana and Nancy) had several years of work experience in the field of science prior to transitioning to teaching through the alternate route. The two female participants taught in the same suburban high school in northern New Jersey and attended the same AR program in northern NJ. One taught two different levels of High School Chemistry and the other taught Biology and Environmental Science.

The male teacher-participant (Henry) conducted undergraduate research in Chemistry prior to transitioning to teaching through the alternate route. The male participant attended a different AR program (AR2) through a university in central New Jersey and taught two levels of High School Chemistry at a suburban high school in central New Jersey.

Both alternate route programs (AR1 and AR2) were hybrid programs that were identified as 75% online and 25% face-to-face. In the online portion of the classes, alternate route teachers engaged in online discussions of the readings and assignments. Face-to-face sessions were comprised of videos, group work, and presentations to each other under the supervision of the professor. AR1 divided their alternate route program into two stages, six courses, and fifteen credits. Stage I was a six week, sixty hour pre-service experience. Stage II was a ten month (September to June), 146 hour instructional period taken concurrently with the first year of teaching. Two pedagogy specific courses, each a three credit course, were titled *Curriculum and Methods* and *Educational Assessment*. AR2 divided their alternate route into three phases based on the calendar year: Phase I being eighty hours of instruction, Phases II and III being sixty hours of instruction. While the phases of AR2 were not divided into courses, curriculum topics were identified. Pedagogy specific curriculum topics included *Instructional Strategies* and *Assessment*. At the time of data collection, all three participants were in the process of completing the last stage/phase of their alternate route program.

Data Collection

Data was collected using in-depth semi-structured interviews, teacher-generated artifacts, and classroom observations (Stake, 1995). All data was collected in the spring of the alternate route teachers' first year of teaching; all participants were in their last phase of their alternate route program.

Semi-structured interviews. Participants were interviewed in the spring of their first year of teaching and asked to recount their alternate route program learning experiences for the year. One forty-five minute face-to-face semi-structured interview was conducted with each participant by this researcher. This interview was conducted three to four weeks prior to the teacher scheduled classroom observation. Interview questions targeted participant adult learning gained from their alternate route program, sensemaking of their learning experiences, and understanding of how their alternate route program was translated to a change in classroom practices. Interviews were audiotaped and transcribed ad verbatim by this researcher. Transcriptions were followed by member checks to ensure that participant experiences were accurately documented and communicated (Stake, 1995).

Teacher-generated artifacts. Teacher-generated artifacts included collection of alternate route program descriptions, syllabi for alternate route courses, as well as lesson plans, teacher worksheets, and teacher notes/class agenda used for instruction during the observation. Teacher-generated artifacts were used to complement participant responses in interviews and observations regarding what learning experiences were offered in the alternate route program and which of these experiences were translated into practice (Hodder, 1994). Teacher-generated artifacts were collected and analyzed to look for evidence of how teachers made sense of their alternate route courses to apply their alternate route learning to their practice. Teacher-generated artifacts were coded using the same consecutive cycles of a priori, descriptive, and pattern coding used for coding the semi-structured interviews, for the same purpose of aggregating data to inform which and how alternate route science teachers' learning experiences were translated into classroom practice.

Classroom observation. One teacher scheduled classroom observation (with a pre- and post-conference) of each participant teaching a science lesson was conducted. Observation times and topics were chosen by the participants with the purpose and intent for the teachers to showcase translation of their alternate route learning into classroom practice. The pre-observation conference was conducted immediately prior to the classroom observation and focused on participants' intended instructional pedagogy, including alternate route science teacher understanding of viable student misconceptions related to lesson concepts, and alternate route science teacher understanding student conceptual understandings of the content prior to the lesson. An observation protocol from Mining Gems (2008), looking for indicators of inquiry, was used during the observation to gather data on which alternate route learning experiences were translated to classroom practice. The post-observation conference was conducted immediately following the observation to document participants' perceptions of achieving lesson outcomes, lesson reflection, as well as how their alternate route program experiences impacted classroom practice and student learning.

Data Analysis

Data analyses focused on understanding participants' learning experiences in order to illustrate what, which, and how elements of their alternate route program were translated into practice. The interview notes, transcriptions, teacher-generated artifacts, and observations were coded in multiple cycles using a priori, descriptive, and pattern coding. A priori codes were generated from pedagogical content knowledge (PCK) components and subcomponents (Park & Oliver, 2008) as an indicator of teacher development as evidenced by translation of learned alternate route experiences into classroom practice.

Descriptive coding illuminated what was seen and heard during the interviews to identify lived experiences that were translated into classroom practice (Miles & Huberman, 1994; Saldaña, 2009). Pattern coding was used to identify patterns regarding which and how alternate route learning experiences were translated into practice. Codes were then clustered into themes to enable the merging of findings in order to generate assertions regarding which and how alternate route science teachers' learning experiences were translated into practice (Miles & Huberman, 1994; Stake, 2006). Being that case study serves to understand phenomena or relationships, categorical aggregation of the data throughout the study provided understanding of the case (Stake, 1995). As such, categorical aggregation of interviews through coding was used to understand which and how alternate route science teachers translated their learning experiences into practice.

Additionally, assertions were generated regarding an emerging theme as to when and how participant alternate route learning experiences translated to instructional practice. Triangulation of interviews, observations, and teacher-generated artifacts was used to help cognize which and how alternate route learning experiences were translated by alternate route science teachers into their classroom practices (Stake, 1995).

Findings

Findings reveal patterns among participant responses that emphasized the limited translation of learned pedagogical experiences from their alternate route programs into classroom instruction during their first year of teaching. Triangulation of data indicated the theme of *relevancy* emerged as being necessary for the participants to translate learned experiences into classroom practice. This section is organized based on common themes and subthemes that emerged surrounding each research question.

Program

In investigating the first research question, findings show that participants were provided courses in their alternate route program that focused on teaching pedagogy. Participants varied in their translation of their learned experiences into classroom practice. Even though data for this study was collected during the spring of the participants first year of teaching while taking their last set of courses in their alternate route programs, participants cited a limited number of learned experiences that were translated into their classroom practice.

Forms of learning experiences. Alternate route program description and syllabi collected from the participants, as well as website review of the programs, indicated that learning experiences addressing potential pedagogical practices for effective teaching were offered by both alternate route programs. Table 8 shows the varied course titles participants experienced including participant responses towards their learned experiences regarding their alternate route classes. Each participant highlighted different aspects of the learned experiences offered in their alternate route programs. Each participant emphasized different understandings of learned pedagogy.

Disproportionate experiences. Participants within the same alternate route program highlighted different elements of learned experiences, as well as different understandings from their alternate route program. For example, Dana and Nancy attended AR1 at the same time and were enrolled in the same alternate route courses, yet reported different understandings and potential translation of these learning experiences. Dana reported learning about diversity, literacy across and within the disciplines, special needs students, differentiated instruction, bullying, counseling services, adolescents, and psychology. Nancy reported learning about adolescents, child development, resources offered in schools, differences between the services offered at public and charter schools, as well as designing lesson plans and curriculum. The only common learning experience highlighted by both participants Dana and Nancy, who were enrolled in the same AR program, was learning about adolescents. Henry attended AR2 and reported learning about Student Growth Objectives, differences in philosophies, giving feedback to students, different teaching techniques (no specifics given), classroom management of students, and differentiated instruction. Dana and Henry attended different alternate route programs and both reported learning about differentiated instruction.

Table 8

Comparison of AR courses relative to each participant

Participant/ AR	AR Course Titles	Participant recounting of AR learned experiences
Dana/AR1	Classroom Management Curriculum and Methods Learning and Motivation Educational Assessment Reading and the School Curriculum	Some basic diversity, cultural diversity, there's a lot of talk about literacy in education; all types, Math, Science, even as well as the regular English literacy. That was a really big topic that was discussed. Some special needs, generic information, and differentiated instruction. Then recently we had to do class presentations where we all presented; there were mixed topics: some were bullying, counseling services, adolescents, psychology.
Nancy/AR1	Classroom Management Curriculum and Methods Learning and Motivation Educational Assessment Reading and the School Curriculum	Currently, we are learning about adolescents and the way children develop; what kind of influences they undergo. We just finished looking at what kind of resources the school offers, in terms of guidance counselors, CST, substance abuse; a lot of alternate route teachers teach in charter schools and they have way different things than we have. We have online discussions about what the school offers, when we are allowed to send kids down, what type of student goes down there, that type of thing. They make us, we were taught, how they want us to design lesson plans and curriculums, which obviously is not how the district wants us to do it.
Henry/AR2	Assessment Content Knowledge Ethical Practice Instructional Strategies Professional Development Learner Development Planning for Instruction Learning Environment Learning Differences Leadership and Collaboration	We talked about writing SGOs, differences in philosophies, giving feedback to students, different teaching techniques. How to handle certain situations if you have a student that's out of line, if you had to differentiate your lessons, you know if a kid is just having a bad day how do you handle it. If a kid just wants to put his head down and you know be there but not there. Just different scenarios and how to handle that.

Specific pedagogical approaches that targeted science instruction were not cited by participants or indicated in the alternate route program information; participants indicated that alternate route learning experiences were not subject specific and varied over the course of the year. As both AR programs enrolled first year teachers from all grade levels and content areas, alternate route learning experiences focused on topics applicable across grades levels and disciplines. Alternate route learning experiences included pedagogical training in differentiation, lesson and curriculum development, instructional strategies, assessment, and providing student feedback.

Learned Experiences

Discrepancies emerged among the three participants specifically on sensemaking of their learned experiences in order to apply them to their classroom practice. Participant responses to interview questions (both semi-structured and post-conference) revealed that much of the learned experiences in participants' respective alternate route programs did not translate to their instructional practice; rather, certain elements of those experiences did. Nonetheless, participants identified their learned experiences differently.

Translated learned experiences. Participants reported that the aspects of learned experiences they carried away from their programs did not translate into their teaching, albeit did provide certain helpful aspects. For example, Dana indicated that knowing about differentiated instruction helped her to understand that different students have different needs. While Dana did not indicate that learning about differentiated instruction in her alternate route courses translated to differentiating her lessons, she indicated that learning about differentiated instruction helped her to chunk information for students. Nancy was enrolled in the same alternate route program at the same time as Dana, but did not identify any of the same learning experiences as Dana; in fact, Nancy stated that none of her alternate route learning experiences helped her in the classroom. A follow-up question to Nancy's response elicited that she felt she gained more from the learning experiences provided by an in-district induction program for new teachers than she did from her alternate route program learning experiences. Henry cited specific activities that he learned in a seminar session. Henry reported a specific instructional strategy (vocab tic-tac-toe) to emphasize student mastery of vocabulary as a learning experience helped him in the science classroom.

For participants to translate alternate route learning experiences into instructional practice, participants had to identify a learning experience that they felt connected to their teaching, conceptualize how to translate the learning experience into practice, and have the time to modify instruction to reveal the translation of their alternate route learning experiences into practice. Furthermore, for participants to translate an alternate route learning experience to their classroom practice, participants had to reflect on how their alternate route learning experiences applied to their classroom practice to make sense of how to translate their alternate route learning into classroom practice.

Dana indicated specifically that she had difficulty translating her alternate route learning to her teaching; she identified that she was translating pieces of her alternate route learning to certain parts of her classroom instruction. When Dana was asked in what way she felt that what she learned in her alternate route courses was being used in practice, Dana indicated:

> "Probably more pieces of it than like, real, real lessons. A lot of it is more experienced-based when I learn something and then if I go back and revisit

> something from alternate route, then I'll start making the connection – ohh, that's what they were talking about. Chunking is probably a really good example of that and differentiated instruction. I read about it, I wrote about it, I researched about it, but I never really understood how to implement it. When I did the lab and was actually able to chunk it successfully, then that's when I was able to make the connection."

Nancy and Henry indicated that they felt they were struggling to translate their alternate route learning experiences into their classroom practice. For instance, Nancy reiterated that she felt her alternate route learning was not being applied to her practice and elaborated that she felt the learning was not beneficial to high school as the learning was geared towards elementary education. Nancy's response revealed that she felt most of the alternate route learning did not pertain to her and therefore she was not seeing how to apply it to her classroom teaching. When Nancy was asked in what way she felt that what she learned in her alternate route courses was being used in practice, Nancy replied, "Really to be honest, nothing. I just don't feel that it's beneficial to any high school teacher not just specifically high school science. Again, they gear all for elementary education."

Henry indicated that his learning about providing individualized feedback to students as quickly as possible was being used in his teaching. However, he indicated that he found difficulty translating his alternate route learning experiences to his classroom practice. He noted:

> "There are times in alternate route where I think I struggle to kind of fit it in. Um, the one thing that probably sticks out is the feedback and just getting that

> individualized feedback to the kids as fast as you can just so they can kind of make the adjustments and you allow them to kind of grow into that learner."

Disconnected commensurable experiences. Participant responses which depict participants' views on why alternate route learning was not translated into classroom practice were culled from both the semi-structured interviews as well as the post-conference interviews. All participants indicated that they could not reconcile where to apply their learning to their practice, citing that the course assignments in their respective alternate route programs were not applicable to their practice in the classroom. All participants conveyed there was a disconnect between the theory they learned and what transpired in the reality of the classroom. Participants indicated that the assignments were seen more as exercises in compliance, as opposed to applicable to their current teaching responsibilities. For example, when asked what was it about her alternate route courses that inhibited her from translating learning from them into practice, Dana responded that:

> "I think it's the application piece that's missing honestly. We do a lot of reading on things, but there is only so much you can read. First year is very overwhelming as it is without having a zillion reading assignments. You write about what you read and we're expected to cite things, I feel it's more of a how to write a research paper sometimes, a formatting exercise than it is what is going to *actually* (teacher emphasis) be useful to me."

Furthermore, Nancy and Henry indicated that due to the diversity of grade levels, subject matter disciplines in their alternate route programs, and the fact that their alternate route courses and assignments were not directly addressing high school science teaching, they had difficulty applying their alternate route learning to their classroom practice. In her responses, Nancy indicated that, “So they kind of forced us to do it their way and learn it their way through the entire stage one, but it wasn’t of any use to us because we all have our own formats.” She also elaborated that, “I think that they aren’t in touch with what’s going on in high schools; it doesn’t translate to the high school level.” She also added that “I think they just don’t gear anything toward what’s actually useful in the classroom, in terms of assignments.”

In his responses, Henry indicated that:

> “There are times in alternate route where I think I struggle to kind of fit it in. Um, just because there is such a mix of teachers. Um, and additionally just the different districts. Because we have people working in Urban District A and Urban District B and other people who are working in you know, Suburban District A and Suburban District B. So just, very, very diverse kind of melting pot of teaching.”

Instructional modifications. Responses by all participants to modifying instructional strategies as a result of their learned experiences in their respective alternate route programs indicated that all participants did not modify instructional strategies as a result of their learning from their alternate route courses. For example, Dana stated that her modification of instructional strategies was based on her experience teaching in the classroom and the responses of the students to her instruction rather than her alternate route learning. Dana indicated that as she gains more experience as a teacher and better understands teaching, she may realize the connection to her alternate route learning at a later time. When asked how she modified her instructional strategies as a result of her learning from her alternate route courses, Dana responded:

> "I really think mine is more by experience. I am modifying and then maybe I'll go back and realize what they were trying to communicate to me later. Yeah, I don't know that, I mean I've tried to some things, like with inquiry, like have the students try to discover things on their own, but actually I didn't find it so successful, especially in science, I find direct instruction a lot more successful than that."

Nancy stated that she had not made any modifications to her instructional strategies as a result of her alternate route learning. Nancy's prior cited response that she did not feel her alternate route learning was being used in practice because she did not feel it was beneficial to a high school teacher was her reasoning as to why she did not modify her instructional strategies as a result of her AR courses. When asked how she modified her instructional strategies as a result of her learning from her alternate route courses, Nancy responded, "I haven't."

Henry reported that he was unsure that he had made any modifications to his instructional strategies as a result of his alternate route learning; he had heard of differentiated instruction and techniques for reaching students from other sources and did not attribute that learning to his alternate route program. Henry attributed his learning about differentiated instruction and techniques for reaching students to prior courses he had taken in college. When asked how he modified his instructional strategies as a result of his learning from his alternate route courses, Henry responded:

> "I don't know that I did. Um, I mean we talked about differentiated instruction. We talked about all these kind of techniques to scaffold and reach every student but it's things I've heard before either in my previous classes or the 24 hour pre-

service or just in speaking with the other teachers. So it's not to say that I didn't get anything from it, but I've already heard it… you know."

While the participants intentionally chose a lesson for observation which would showcase how they applied their alternate route learning to their classroom practice, participant responses indicated that they did not identify varied alternate route program learning experiences regarding application of their alternate route learning to their practice. Participants did not present specific examples in their classroom instruction or any explanations as to how they translated specific alternate route program learning experiences to their practice.

Participants were also asked how they had translated their alternate route program learning to their classroom practice during the post-observation conference. When asked during the post-observation conference how she saw her alternate route program learning experiences impacting her classroom practice and subsequently student learning, Dana indicated "Not much for this lesson; this was math and graphical based. Moving forward, literacy and word problems, learning to read problems. No need for differentiated instruction during this lesson."

In conjunction with the classroom observation, teacher-generated artifacts (handouts distributed to the students during the observation) were collected and how these artifacts represented translation of alternate route course learning into practice was discussed during the post-observation conference. Dana's first teacher-generated artifact collected during the observation was a two question quiz. Dana's second teacher-generated artifact collected during the observation was a lab to help students understand the targeted content. Dana indicated in her post-observation conference that her alternate route courses did not impact this lesson because she identified literacy and summarization strategies as the key understandings from her alternate route program. As the observed lesson was math and graphical based, she did not apply her alternate route learning about literacy and summarization strategies. Since she did not see the application of literacy and summarization strategies to this lesson, she did not translate her alternate route learning to the observed lesson.

When asked during the post-observation conference how she saw her alternate route program learning experiences impacting her classroom practice and subsequently student learning, Nancy indicated that she provided a variety of learning mediums during the lesson as a means to appeal to the variety of learners in the classroom by her response, “Appealing to every type of learner; that was the reason for use of the video, to reiterate information.”

Nancy’s first teacher-generated artifact collected during the observation was a think-pair-share activity for students to answer questions designed to review and elicit their understanding of the targeted content. Nancy’s second teacher-generated artifact collected during the observation was a lab provided to the students depicting the background information, objective, materials, procedure, tables for documenting a series of observations of pictures, data provided in the lab handout, as well as analysis and interpretation questions. Nancy indicated that her use of the think-pair-share, followed by a video which outlined the content to be addressed in the lab, followed by the lab, was her application of her alternate route learning about appeasing every type of learner (multiple learning styles in the classroom). Additionally, Nancy indicated that the think-pair-share activity at the beginning of her observed lesson and the cooperative group work students engaged in during the lab was an application of her alternate route learning. None of these learning experiences were cited by Nancy as demonstrating her application of her learning from her alternate route courses.

When Henry was asked during the post-observation conference how he saw his alternate route program learning experiences impacting his classroom practice and subsequently student learning, Henry responded:

> "Adjusting on the fly. Modifying lessons and assignments based on feedback from the students. Give me a 1-5 for understanding hand gestures (*as a means of formative assessment*). Since there is such a diversity of teachers in the program and it is mostly elementary teachers, it's like apples and oranges."

Henry's teacher-generated artifact collected during the observation was a series of problems on a worksheet. Henry indicated that this artifact represented application of his alternate route learning in that the problems were scaffolded for difficulty as the students progressed through the worksheet to engage all learners, as well as the fact that students were assigned to small groups based on their response to a targeted question designed to formatively assess their current understanding of this content (differentiation). Differentiation was cited in Table 8 as one of Henry's alternate route learning experiences.

Analysis of Findings

The theme of relevancy emerged as a result of triangulation of findings of data sources. Relevancy indicated how the participants saw the connection between their alternate route program learning and their classroom practice, how they made sense of their learning to translate and apply their alternate route program learning to their classroom practice, and how they saw their classroom practice changing as a result of learning in their alternate route program.

Relevancy

Relevancy was observed as being fundamental to alternate route science teachers' learning experiences being translated into classroom instruction. The participants indicated that finding relevancy between their alternate route learning experiences and classroom teaching responsibilities determined their ability to translate a learning experience from their alternate route program to classroom practice. Relevancy for the alternate route science teacher participants was determined by how meaningful their alternate route learning experience was to their classroom responsibilities and practice. For example, Dana indicated that many of her learning experiences were more relevant for an English or history setting than a science setting. Because she did not find the learning experiences relevant to her science classroom, Dana did not see the application of this learning to her science classroom. Henry and Nancy noted that their alternate route programs were dominated by elementary alternate route teachers and rarely included experiences or examples connected to their secondary context. In effect, many of the alternate route program discussions, tasks, and learning experiences were perceived to lack relevance to their current classroom assignments. As evidenced by the interview and post-observation conference responses documented in Table 9, relevancy was deemed to be necessary for learning experiences to be translated into practice.

Table 9

Participant responses that indicate relevancy is necessary for translating AR learning into practice

Participant	Participant Responses
Dana	But I do find a lot of the things in the alternate route class that they do recommend are really applicable for elementary settings or history and English settings and not so much science. So some of the tools they have in maps and worksheets are awesome but they would never, I could never figure out a way for them to apply here. I do real direct problems so a lot of the summarizing strategies would be more applicable to an English or history setting rather than a science setting. Some of the concept maps again, more applicable to English and history than science. A lot of it is based on literacy so they are focusing a lot on that. They're focusing a lot on papers. So, writing about adolescent psychology, making a list of resources that you can use to inform your science literacy, or literacy resources from the school. There's a lot of projects with that. We had to design a curriculum unit. I feel like it's a lot of projects and right now as a first year and as someone who wasn't traditionally trained, everything is so on the fly and experienced-based, you kind of feel like you're drowning with the amount of work that they give you.
Henry	We have elementary to high school. Um, so what works in a K-3 class might not work in high school. So, I have a lot of difficulty relating to kind of other people and how they go about it. Since there is such a diversity of teachers in the program and it is mostly elementary teachers, it's like apples and oranges.
Nancy	It's geared a lot toward middle school. Most of the teachers are middle school or elementary education so it's geared a lot towards 5-8; and it doesn't translate to the high school level. The majority of the people in our class are K-8 so they gear everything towards K-8, concentrating on 5-8. So you can't really translate that into high school, it's not the same stuff, we don't see the same problems, we don't go through the same steps, it's all different.

Moreover, all participants noted that their respective alternate route program advertised courses which provided pedagogical learning experiences that would lend themselves to application to the classroom. Findings indicate that translation of an alternate route learning experience to classroom practice was based on participants' ability to make sense of their learning experience and see its application to their teaching.

Furthermore, participants indicated that because they did not see the relevancy between their alternate route learning and their practice, they did not translate their learning from their alternate route courses to their classroom practice. Participants described this as mainly due to the fact that participants were not asked to apply their learned experience in their alternate route courses to their specific learning context. For example, Dana indicated that she felt the application piece was missing from her alternate route courses, and rather that the assignments were reading and writing exercises to be completed for the program (see Table 10). Dana also indicated that the first year of teaching was overwhelming, which in turn, hindered her ability to translate her alternate route program learning to her classroom practice.

Moreover, Henry attributed his lack of translation of alternate route experiences into classroom practice to time constraints from state testing and evaluation responsibilities. Both Dana and Henry mentioned that limited time to plan for translation was a factor for them in light of daily teaching responsibilities and alternate route program coursework. Furthermore, they both indicated that the daily responsibilities of teaching in the first year prohibited them from translating their learning to practice. However, Nancy did not mention time being a factor. Nancy attributed her inability to translate her alternate route program experiences to her classroom practice was due to her perception that the alternate route course assignments were geared towards elementary and middle school. Nancy claimed that her issues and problems in high school were very different from those in middle school.

Table 10

Participant responses as to why AR learning was not translated into classroom practice

Probing questions	Participant responses
Interviewer: What do you think it is about the alternate route courses that sort of prevent you or don't help you translate learning into practice?	Dana: I think it's the application piece that's missing honestly. We do a lot of reading on things, but there is only so much you can read. First year is very overwhelming as it is without having a zillion reading assignments. You write about what you read and we're expected to cite things, I feel it's more of a how to write a research paper sometimes, a formatting exercise than it is what is going to *actually* (teacher emphasis) be useful to me. Whereas the X [*name of in-district PD]* workshops were more skill based; I'll model it for you and now you practice it.
Interviewer: Did you use that in the classroom?	Henry: Not yet. I'm trying to still implement it. I'm definitely looking to implement it in the fourth marking period. It was just kind of a crazy time with PARCC, SGOs, and we kind of… I was just trying to deal with all that. But I'm definitely interested in using it in my fourth marking period.
Interviewer: Why do you say that?	Nancy: It's geared a lot toward middle school. Most of the teachers are middle school or elementary education so it's geared a lot towards 5-8; and it doesn't translate to the high school level. The majority of the people in our class are K-8 so they gear everything towards K-8, concentrating on 5-8. So you can't really translate that into high school, it's not the same stuff, we don't see the same problems, we don't go through the same steps, it's all different.

Discussion and Implications

In accordance with prior research, findings from this study demonstrate that there exist problems for first year teachers specifically in their ability to translate pedagogical practices learned into their classroom practice (Darling-Hammond et al., 2001). Participants in this study had difficulty making sense of their alternate route program learning experiences and therefore indicated difficulty in translating those experiences into their classroom pedagogy. Participants specified that their alternate route learning experiences, especially discussions and assignments, had little to no direct correlation to their current practice in the classroom and therefore participants were unable to see the relevance of their alternate route learning experiences to their classroom practice. In effect, participants did not modify classroom instruction in accordance with their alternate route program learning. Furthermore, alternate route science teachers found difficulty in finding and making time for the reflection required to modify their instructional strategies as a result of engaging in their alternate route program learning experiences. Participants indicated that day to day responsibilities of teaching, in conjunction with transitioning to a new career (teaching), afforded them little to no time to reflect on their learning.

Emerging Themes in Translation

Participant responses regarding their alternate route program learning experiences generated themes regarding understanding of their students, the structure of and resources provided by schools, and pedagogy. Alternate route program learning experiences such as diversity, psychology, adolescent development, and addressing passive learners (identified as students not engaged in class) had the potential to help participants understand the growth and development of their students. Although participants cited engaging in these learning experiences to better understand their students, none of the participants spoke to how they used the information and learned experiences they were exposed to in their programs to approach or modify instruction.

Alternate route program learning experiences regarding counseling services, child study team, substance abuse, support for students, had the potential to help participants provide support for students outside the classroom and also had the potential to be leverage for supporting academic growth of students. Knowledge of the resources a school offers to students and to whom to speak with if there was a concern about a student is necessary for a teacher to address the needs of the whole child. Again, when responding to questions involving translation of alternate route program learning experiences into classroom practice, none of the participants spoke to how they used their knowledge of school resources in their practice.

Alternate route program learning experiences that fell under the theme of pedagogy included differentiated instruction, disciplinary literacy, providing student feedback, designing lesson plans, and curriculum. While participants were exposed to courses which provided instruction on pedagogy for teaching, and while alternate route program learning experiences included pedagogical training in differentiation, lesson and curriculum development, instructional strategies, assessment, and providing student feedback, when questioned about which alternate route program learning experiences they translated into practice, participants indicated limited translation of their experiences; differentiated instruction, chunking, knowledge of special needs, and a specific vocabulary reinforcement instructional strategy.

As will be discussed in subsequent sections below, participants needed to see their alternate route learning as being directly relevant to their current teaching in order to make sense of the alternate route learning and successfully translate it into classroom practice. Such findings are supported by prior literature such as Glynn and Koballa (2005) whose study on contextual teaching and learning indicated that "beginning science teachers often have difficulty relating various theories and methods taught in courses to what actually happens in their daily teaching practice" (p. 82).

Sensemaking and Adult Learning for Translation

As indicated above, participants had difficulty making sense of their assignments in relation to their current teaching. This emerged as a theme of relevancy. When participants did not see a connection or application of their alternate route program learning to their classroom practice then they did not translate their alternate route program learning experiences to their practice. Since the alternate route program cohorts contained elementary, middle school, and high school alternate route teachers, the high school teacher participants of this study had difficulty connecting and relating their alternate route discussions and assignments to their high school classroom setting.

Nancy struggled the most of the three participants with making sense of her alternate route program learning and subsequently, she could not cite any examples of translating her alternate route learning experiences into practice. She did not see the direct connection between her alternate route program learning assignments and her teaching; she perceived that most of the alternate route learning was geared towards elementary and middle school teachers.

Additionally, since none of their alternate route program learning experiences were specific to science instruction, all three teachers indicated that they struggled with reconciling the conversations and assignments. Much of these, they claimed were general in nature, were not district specific/aligned in format and content, or were what they perceived to be strategies effective for use in other disciplines. In their book on the adult learner, Knowles, Holton, and Swanson (2000) specify that adult learners need to see the relevancy of their learning in order to learn something. They further describe that adult learners learn most effectively when new learning is presented in real contexts and adult learners have the time to connect their new learning to prior understanding.

For teachers, integrating theory into practice to modify their instruction is an iterative process of evaluating specific classroom situations, student interactions with the content, and determining when and how to use their professional learning experiences to inform a change in practice (Darling-Hammond et al., 2001; van Driel, Verloop, & De Vos, 1998; van Driel, De Jong, & Verloop, 2002). The participants in this study were in the beginning stages of this iterative process and would benefit from ongoing support for determining when and how to use their professional learning experiences to inform a change in practice. In effect, findings demonstrate implications for practice, policy and research.

Implications for Practice

Historically, alternate route programs were one means to increase the number of science teachers in the teaching pool. In addition, it is important for educational institutions and administrators who support science teacher development to better understand how alternate route science teachers develop their pedagogy as teachers.

Further knowledge of what, which, and how alternate route science teachers' learning experiences translate into practice and can inform which professional learning opportunities are offered or required to support their development as teachers. Identifying the learning experiences that are translated into practice for alternate route science teachers can assist those who support alternate route science teachers in designing learning experiences to promote the development of alternate route science teachers, and in turn, promote student achievement. By looking at which alternate route science teachers' learning experiences were translated into practice, it is possible that the conclusions from this study could identify elements of alternate route programs that facilitate teacher effectiveness.

As such, the findings from this study suggest that first year alternate route science teachers need to be exposed to more meaningful applications of learned experiences in their alternate route program to actual practice. They need to make connections between the learning in their alternate route courses and their teaching responsibilities. Additionally, they need to see their alternate route learning experiences as being relevant to their teaching in order for translation into instructional practice to occur.

The findings from this study support Leithwood and Jantzi's (2006) assertion that "there is a significant gulf between classroom practices that are 'changed' and practices that actually lead to greater pupil learning; the potency for leadership for increasing student learning hinges on the specific classroom practices that leaders stimulate, encourage and promote" (p. 223). For alternate route science teachers to apply their learning to their practice, alternate route programs and district leaders need to assist these new teachers in making sense of their alternate route learning, in seeing the relevance of the new learning to their practice, as well as its application to their instruction.

Implications for Policy

Policy decisions regarding supporting alternate route science teachers during their first years of teaching can be aided by understanding how alternate science teachers' learning experiences in such programs translate into classroom practice (Feistritzer, 2009; Grossman & Loeb, 2010; Kee, 2012). By understanding which and how alternate route science teachers' learning experiences are translated into practice, this research can inform policy surrounding alternate route programs and the learning experiences they provide to support and promote alternate route teacher development and effectiveness. Likewise, findings from this research could inform policy surrounding the design of learning experiences for traditional route teacher preparation programs.

As such, findings from this study suggest that alternate route teachers would benefit from alternate route programs examining their programs for the course offerings and progression of courses offered in order to intentionally structure their program to be in alignment with the teaching responsibilities of the participants. By doing so, alternate route learning experiences may be seen as more applicable to alternate route science teachers' practice and will therefore more likely be translated into classroom practice.

Alternate route programs may better serve alternate route teachers by differentiating assignments to intentionally connect learning to practice for these new teachers. For example, the policy of engaging K-12 teachers at the same time for all of the alternate route courses may need to be re-evaluated, as this policy can hamper participants' ability to translate their alternate route learning into classroom practice.

Since the alternate route program is the means by which alternate route science teachers attain their pedagogical knowledge for teaching, knowledge of the importance of relevancy and application of new learning in order to translate this learning into practice adds to the literature surrounding science education pedagogy (Keeley, 2005; Loucks-Horsley et al., 2010; Mundry et al., 2010).

Implications for Research

Further research can look into comparing elements within traditional and alternate route programs and how such elements can be modified to better address the development of teachers within such programs. For science teachers to be effective in the classroom, they must have knowledge about science learners, curriculum, instructional strategies, and assessment through which they can transform their knowledge of science into effective teaching and subsequent learning by their students (Abell, Rogers, Hanuscin, Lee, & Gagnon, 2009). As relevancy played a key role in ensuring translation of learning experiences into classroom practice, ensuring novice teachers explicitly recognize how their learning applies to their practice needs to be a major component of designed professional learning experiences. More research is needed to elicit which alternate route learning experiences are deemed most relevant by alternate route science teachers and which learning experiences that are translated into practice best promote student learning.

Conclusion

This case study researched lived and extended learning experiences of alternate route science teachers to understand which and how learning experiences from their alternate route program were translated into practice. This study researched what learning experiences were offered by alternate route programs and which learned experiences from their alternate route program were translated into practice by first year alternate route science teachers. In doing so, this study engendered deeper understanding of how teacher educators can compel teachers to think more critically about their practice and the reasons for their instructional strategies in light of student performance. Focusing on promoting development in alternate route science teachers can, in turn, improve their effectiveness in the classroom and consequently, facilitate greater student achievement in science.

Findings from this study reveal patterns among participant responses that a limited number of learned pedagogical experiences from alternate route programs were translated into classroom instruction. Participants were unable to connect much of their coursework to their practice; unable to see the application of their alternate route learning to their practice. Relevancy appeared to play a pivotal role in ensuring translation of teacher learning into practice. Continued research is necessary to tease out the elements of alternate route programs, as well as traditional teacher preparation programs, which best promote teacher development.

Chapter 6

Exploring how alternate route science teachers' alternate route program learning experiences facilitated their pedagogical content knowledge development

Abstract

This purpose of this qualitative case study was to understand how alternate route first year science teachers' learning experiences gained from their alternate route courses facilitated the development of their pedagogical content knowledge. A research question studied was what elements contribute to alternate route science teachers' learning experiences that in effect, facilitate the development of their pedagogical content knowledge? Participants included three first year high school teachers from two alternate route program institutions. Data collection and analyses focused on semi-structured interviews, classroom observations, and teacher-generated artifacts. Findings show that participant alternate route program learned pedagogical experiences were not perceived to have attributed to participants' pedagogical content knowledge. Triangulation of data indicated the theme of reflection as a key requirement for the development of alternate route science teachers' pedagogical content knowledge. Findings from this study inform understandings of how teacher participant learning experiences from alternate route programs facilitated teacher pedagogical content knowledge development in novice teachers.

Keywords: alternate route, teacher development, pedagogical content knowledge

Context of Study

In response to the call for educational reform in science beginning in the 1980s, professional development resources and books were written to assist in building the capacity of teachers to improve their science instructional practices (Keeley, 2005; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010; Michaels, Shouse, & Schweingruber, 2008). Additionally, teacher quality has a powerful influence on student achievement (Leithwood, Louis, Anderson, & Wahlstrom, 2004; Wei, Darling-Hammond, & Adamson, 2010). A continued focus on effective professional learning by teachers is warranted because the "efforts to improve student achievement can succeed only by building capacity of teachers" (Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009, p. 7). In an attempt to address the fact that "little is known about the mechanisms through which professional development works to improve instruction" (Epstein, 2004, p. 157), this study attempts to further understand how first year alternate route science teachers' alternate route program learning experiences are translated to classroom practice.

Alternate Route Teachers

Science teaching positions are difficult to retain with teachers who earn their teacher certification through the traditional methods due to high attrition and migration rates (Ingersoll & Perda, 2010). The problem of retention, coupled with problems of quality from traditional undergraduate teacher preparation programs in the 1980s, sparked the establishment of New Jersey's alternate route program for teacher certification in 1984 (Klagholz, n.d.). Goldhaber and Brewer (2000) and Klagholz (2000) define an alternate route teacher as a person who graduated from college with a degree other than education and who transitioned to teaching in a classroom without formal training in education besides that required to obtain a provisional license to teach. For example, a person might have a degree in chemistry but no coursework in education. Alternate route programs provide an expedient means for career-changers to enter the teaching profession. Alternate route teachers can receive from 24 hours to up to 8 weeks of teaching preparation prior to beginning full-time teaching and that preparation continues part-time during their first year of employment as a teacher (Johnson, Birkeland, & Peske, 2005). In New Jersey, each alternate route certification applicant is required to: (1) obtain a baccalaureate degree with a major in the subject to be taught; (2) demonstrate subject competency by passing the relevant subject test of the Praxis II Exam[3]; and (3) acquire and demonstrate teaching skill by completing a mentor-assisted, school-based internship (Certificate Subject Area/Grade Level & Codes, n.d.; Klagholz, 2000). A certificate of eligibility is issued once an alternate route candidate meets all the requirements for the specific endorsement and the certificate of eligibility authorizes the candidate to seek and accept employment in a New Jersey public school (State of New Jersey Department of Education, 2010). Once obtaining a certificate of eligibility and gaining full-time employment, the alternate route teacher receives support from a mentor teacher during the initial year of teaching while completing course work at an alternate route program training site. School administration monitors and evaluates the alternate route teacher's development and classroom performance, and at the end of the year, recommends whether or not the state should issue standard certification to the candidate

[3] The Praxis II Exam measures subject-specific content knowledge, as well as general and specific teaching skills necessary for beginning teachers (Educational Testing Service, 2014).

(Klagholz, 2000; New Jersey Department of Education, 2014; State of New Jersey Department of Education, 2010).

The National Center for Alternative Certification (2010) cited that "approximately one-third of new teachers being hired are coming through alternative routes to teacher certification" (National Center for Alternative Certification, 2010, Introduction, para. 1). According to data provided by the New Jersey Department of Education, the percentage of alternate route science teachers over the last ten years ranged from 33% to 69% with the average indicating that alternate route science teachers comprised 54% of the science teaching pool over the last ten years (R. Higgins, personal communication, September 3, 2014). Feistritzer (2009) asserts that the success of the alternate routes to teacher certification programs is due to the fact that they "are market-driven. They have been created all over the country to meet [the] demand for specific teachers in specific subject areas at specific grade levels in specific schools where there is a demand for teachers" (Feistritzer, 2009, p. 4). However, little is noted in the literature about alternate route teachers' pedagogical success in the K-12 classroom.

Although science teachers enrolled in alternate route programs have taken more courses in their content discipline in comparison to teachers who complete traditional teacher education programs, science teachers enrolled in alternate route programs have not engaged in the same pedagogical training as teachers who complete traditional teacher education programs. As such, it is important for educational institutions in general, and administrators who support teacher development in particular, to better understand the factors that support alternate route science teachers in developing into effective teachers.

Promoting Science Literacy

Due to the growing concern over the United States' lack of performance on national and international assessments such as the NAEP and TIMSS, reform in science education is focusing on building science literacy (American Association for the Advancement of Science, 1990; Michaels, Shouse, & Schweingruber, 2008; National Research Council, 2007; Sadler, 2006). A *Framework for K-12 Science Education* (National Research Council, 2012) states that

> the committee thinks that developing a scientifically literate citizenry is equally urgent. Thus the framework is designed to be a first step toward a K-12 science education that will provide *all* students with experiences in science that deepen their understanding and appreciation of scientific knowledge and give them the foundation to pursue scientific or engineering careers if they so choose. (National Research Council, 2012, p. 298)

In order to do so, it is important to understand how teachers' alternate route learning experiences can promote scientific literacy in the classroom and what teacher learning experiences best promote science literacy.

Pedagogical Content Knowledge

In light of the fact that alternate route science teachers do not have formal teaching experiences prior to their placement in a classroom, their lack of teaching experience may or may not impede their effectiveness as teachers in the classroom. To date, research in this area is inconclusive. Since one purpose of alternate route programs is to ensure that qualified teachers are placed in science classrooms, understanding the learning experiences of alternate route science teachers and how they inform their PCK development is paramount to supporting the success of alternate route science teachers in the classroom (Feistritzer, 2009).

Shulman (1986) conceptualized and defined pedagogical content knowledge (PCK) as the knowledge of subject matter *for teaching* (Shulman, 1986, p. 9). PCK includes teacher understanding of student preconceptions and misconceptions about the subject matter, as well as what makes the learning of specific topics easy or difficult (Shulman, 1986). Additionally, to promote student achievement, PCK for teachers must include appropriate strategies to promote student acquisition of the learning outcomes in a lesson (Bransford at al., 1999; Shulman, 1986).

Park and Oliver (2008) identified that PCK development incorporates knowledge acquisition and knowledge use, such that teachers develop PCK through a dynamic relationship between knowledge acquisition, new applications of that knowledge, and reflection on the uses of that knowledge in practice. Being that subject matter knowledge and teaching experience play a role in PCK development, understanding how a prospective teacher's existing PCK will be applied to their teaching are critical for ensuring a better understanding of which and how alternate route science teachers' learned experiences promote their PCK development. As a result, this study used Shulman's (1986) theoretical framework for PCK in the design of data collection tools, as well as data analysis.

Theoretical Framework

To address the purpose of this study, it was essential to understand how teacher participants made sense of the pedagogical experiences they learned from their alternate route program, and how such experiences were perceived to inform their PCK development. This study relied on varied theoretical frameworks in order to gain a holistic understanding of the experiences to which participants were exposed. To this end, methodology and data analysis relied on the use of adult learning theory (Loucks-Horsely et al., 2010) and sensemaking theory (Weick, Sutcliffe, & Obstfeld, 2005, Weick, 2012), in conjunction with Shulman's (1986) theoretical framework on pedagogical content knowledge (PCK). These frameworks were used to understand teacher participant experiences and how teacher participants made sense of those experiences. Additionally, Shulman's (1986) theoretical framework on PCK was used to inform the design of the research questions and was the lens through which data was collected, analyzed and interpreted.

Pedagogical Content Knowledge

Through the use of Shulman's (1986) theoretical framework on PCK, in conjunction with adult learning theory (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010), and sensemaking theory (Weick, Sutcliffe, & Obstfeld, 2005, Weick, 2012), this study generated an understanding of how alternate route science teachers perceived their alternate route program learning experiences facilitated their PCK development. Shulman's (1986) theoretical framework on PCK was used in the design of the interview questions and observation protocol to collect data on how adult learning facilitated the development of PCK among alternate route science teachers. This study did not focus on the beliefs teachers had regarding the value of their alternate route experience.

Shulman (1986) conceptualized and defined pedagogical content knowledge (PCK) as the knowledge of subject matter *for teaching* (Shulman, 1986, p. 9). According to Shulman (1986), teacher experiences are centered on their mastery of three types of knowledge (a) content, also known as "deep" knowledge of the subject itself, and (b) pedagogical content knowledge (i.e. content knowledge beyond subject matter that Shulman describes as the content knowledge for teaching) and (c) knowledge of the curricular development. PCK includes teacher understanding of student preconceptions and misconceptions about the subject matter, as well as what makes the learning of specific topics easy or difficult (Shulman, 1986).

Park and Oliver (2008) identified that PCK development incorporates knowledge acquisition and knowledge use, such that teachers develop PCK through a dynamic relationship between knowledge acquisition, new applications of that knowledge, and reflection on the uses of that knowledge in practice. Park and Oliver (2008) found that teachers produce PCK through their own teaching experiences and the most powerful changes to their PCK are a result of these experiences in practice.

Although Shulman introduced the concept of PCK in 1986, not much is identified from research about the manner of PCK development by beginning teachers and how to facilitate PCK development (De Jong, Van Driel, & Verloop, 2005). This study aimed to elucidate how alternate route science teachers’ alternate route program learning experiences developed their PCK to promote student attainment of their lesson targets. In doing so, this study engendered deeper understanding of how supporters of teachers can facilitate PCK; how teachers can be encouraged to think more critically about their practice and the reasons for their instructional strategies in light of student performance. Focusing on promoting PCK development in alternate route science teachers can, in turn, improve their effectiveness in the classroom and consequently, facilitate greater student achievement in science.

Adult Learning Theory

Since alternate route science teachers have not had pedagogical training prior to entering a classroom, they need professional learning experiences in order to understand the needs of their students, so as to facilitate student learning (Darling-Hammond, Austin, Orcutt, & Rosso, 2001; Davis, 2003; Spang, 2008). Since alternate route science teachers do not have the teaching experiences from which to develop their ideas and skills for masterful teaching in the classroom, and since "contemporary learning theory recognizes the role that both experience and reflection play in the development of ideas and skills" (Darling-Hammond et al., 2001, p. 9), a key feature to alternate route science teacher PCK development would be the alternate route program learning experiences from which they draw when formulating new ideas for teaching.

Adult learning is a cycle promoted through purposeful design of a learning environment that progresses through an invitation to learn, or engagement, to experience, to reflection, and evaluation (Loucks-Horsley et al., 2010). This research looked through the lens of adult learning to discern the systems of adult learning or particular learning experiences that alternate route science teachers perceived to promote their PCK development.

Sensemaking Theory

The study also used sensemaking theory to address how alternate route science teachers made sense of alternate route program learning experiences in order to translate these experiences into classroom practice, and in turn, develop their PCK. Weick, Sutcliffe, and Obstfeld (2005) describe sensemaking as a process of socially constructing plausible meanings that rationalize action when discrepant cues interrupt a person's ongoing activity. Sensemaking theory helped inform assertions regarding how alternate route science teachers made sense of their adult, professional learning, in order to develop their PCK. Sensemaking is “a largely invisible, taken for granted social process” (Weick et al., 2005, p. 417). As such, this study aimed to make visible alternate route science teachers’ sensemaking of their alternate route program learning.

Method

The purpose of this qualitative case study was to investigate how alternate route science teachers’ learning experiences in their alternate route program facilitated the development of their pedagogical content knowledge (PCK). This research generated an understanding of how participants perceived their alternate route program learning experiences informed the development of their PCK. The setting was alternate route programs that enroll students seeking science teacher certification in New Jersey. Participants in this study were first year alternate route science teachers chosen through purposeful sampling. Data collection included semi-structured interviews, teacher-generated artifacts, and observations in an effort to understand how alternate route science teachers’ learning experiences translated into classroom practice. As a result, this study investigated the following research question: What elements contribute to alternate route science teachers’ learning experiences that in effect, facilitate the development of their pedagogical content knowledge?

As identified by Stake (1978), the target of a case study is to gain an “understanding, extension of experience, and increase in conviction in that which is known” (Stake, 1978, p. 6). Stake (2006) also explains that “case study was developed to study the experience of real cases operating in real situations” (Stake, 2006, p. 3). “Cases of interest in education … are people and programs; … we seek to understand them for both their uniqueness and commonality" (Stake, 1995, p. 1). A case study was appropriate for this research because the goal of this research was to understand how alternate route science teachers' lived experiences (when they are in the alternate route program) and extended experiences (when they are teaching) translated into classroom instructional practices and facilitated their development as teachers. Case study helped generate understanding of the elements necessary to promote PCK development of alternate route science teacher participants from their alternate route program learning.

In alignment with qualitative data analysis techniques described by Creswell (2007) and Stake (1995), categorical aggregation of the data was conducted to draw key meaning from the data, to search for patterns, and to develop assertions regarding which alternate route program learning experiences were translated into classroom practice.

Key assumptions in this study were that alternate route science teachers made sense of their alternate route program learning experiences and articulated how their learning translated into practice. Since understanding the lived and extended learning experiences of alternate route science teachers was the focus of this research, case study was the appropriate methodology for documenting, interpreting, and communicating these experiences (Stake, 1995; Stake, 2010).

Setting and Participants

Participants included two female high school science teachers and one male high school science teacher enrolled in two different institutions that provided alternate route programs in New Jersey. In keeping with qualitative study being focused on the experiences of the individual participants, but to ensure confidentiality, pseudonyms were assigned to participants when reporting the data.

The two female teacher-participants (Dana and Nancy) had several years of work experience in the field of science prior to transitioning to teaching through the alternate route. The two female participants taught in the same suburban high school in northern New Jersey and attended the same AR program in northern NJ. One taught two different levels of High School Chemistry and the other taught Biology and Environmental Science.

The male teacher-participant (Henry) conducted undergraduate research in Chemistry prior to transitioning to teaching through the alternate route. The male participant attended a different AR program (AR2) through a university in central New Jersey and taught two levels of High School Chemistry at a suburban high school in central New Jersey.

Both alternate route programs (AR1 and AR2) were hybrid programs that were identified as 75% online and 25% face-to-face. In the online portion of the classes, alternate route teachers engaged in online discussions of the readings and assignments. Face-to-face sessions were comprised of videos, group work, and presentations to each other under the supervision of the professor. AR1 divided their alternate route program into two stages, six courses, and fifteen credits. Stage I was a six week, sixty hour pre-service experience. Stage II was a ten month (September to June), 146 hour instructional period taken concurrently with the first year of teaching. Two pedagogy specific courses, each a three credit course, were titled *Curriculum and Methods* and *Educational Assessment*. AR2 divided their alternate route into three phases based on the calendar year: Phase I being eighty hours of instruction, Phases II and III being sixty hours of instruction. While the phases of AR2 were not divided into courses, curriculum topics were identified. Pedagogy specific curriculum topics included *Instructional Strategies* and *Assessment*. At the time of data collection, all three participants were in the process of completing the last stage/phase of their alternate route program.

For qualitative research, sample size is justified by reaching data saturation (Saumure and Given, 2008). “Saturation is the point in data collection when no new or relevant information emerges,” in this study, with respect to the case and its elements (Saumure and Given, 2008, p. 196). This researcher was confident that the sample size was large enough to ensure trustworthiness of the study when she sensed that she had seen and heard the data repeatedly and additional data would not add interpretive value to the case (Sandelowski, 2008).

Prior to choosing participants, a call for study participation was sent out to institutions across New Jersey that offered alternate route programs. Sample participants were identified through purposeful sampling via correspondence with New Jersey school district science supervisors. Six respondents replied to the call for participation. Of the six respondents, the three described above ultimately consented to participate in the study. Science teachers in an alternate route program and their first year of teaching allowed for study of how alternate route science teachers’ alternate route program learning experiences translated to their classroom practice.

Data Collection

Data was collected using in-depth semi-structured interviews, teacher-generated artifacts, and classroom observations (Stake, 1995). Semi-structured interviews were designed to elicit participant perspectives and lived experiences in their alternate route programs in order to understand how interviewee's alternate route experiences translated to the science and how participant perceived their alternate route courses to have promoted the development of their PCK. Teacher-generated artifacts, or the documents used/created by the teachers in this study, were used to reveal the learning experiences of the alternate route program, as well as how the participants translated these learning experiences to their science classroom practice. Classroom observations of alternate route science teachers conducted by this researcher were used to look for and discuss instances of translation of learned experiences to classroom practice, as a means to understand alternate route science teacher PCK development. Classroom observations provided data that added to and supported the data collected through interviews and teacher-generated artifacts. All data was collected in the spring of the alternate route teachers' first year of teaching; all participants were in their last phase of their alternate route program.

Semi-structured interviews. Semi-structured interview questions focused on gaining perspectives and insights of participant perceptions regarding what, which, and how alternate route learning experiences were translated into their classroom practice, as well as which learning experiences helped to promote their PCK (Stake, 2010). One forty-five minute face-to-face semi-structured interview was conducted with each participant by this researcher. Interviews were audiotaped and transcribed ad verbatim by this researcher. Transcriptions were followed by member checks to ensure that participant experiences were accurately documented and communicated (Stake, 1995).

Teacher-generated artifacts. Teacher-generated artifacts included collection of alternate route program descriptions, syllabi for alternate route courses, as well as lesson plans, teacher worksheets, and teacher notes/class agenda used for instruction during the observation. Teacher-generated artifacts were used to complement participant responses in interviews and observations regarding which alternate route program learning experiences helped to promote their PCK (Hodder, 1994). Teacher-generated artifacts were collected and analyzed to look for evidence of how teachers made sense of their alternate route courses to inform their PCK development.

Classroom observation. One teacher scheduled classroom observation (with a pre- and post-conference) of each participant teaching a science lesson was conducted to gather data on which and how their alternate route program learning experiences were translated and applied, as evidenced by classroom practice. Observation times and topics were chosen by the participants with the purpose and intent for the teachers to showcase translation of their alternate route learning into classroom practice.

Additionally, a PCK rubric (Park, Jang, Chen, & Jung, 2011) (see Appendix G) was used to gather data regarding the observed teacher's PCK during the observation, as well as during analysis of the observation protocol to identify evidence of PCK during the observation. The PCK rubric was generated in alignment with the five components of PCK (Park & Oliver, 2008). The five components of PCK are (1) orientations to science teaching, (2) knowledge of K-12 students' understanding in science, (3) knowledge of science curriculum, (4) knowledge of instructional strategies and representations for teaching science, and (5) knowledge of assessments of science learning (Park & Oliver, 2008). The PCK rubric "is an instrument to measure the level of a teacher's PCK based on observations of the teacher's teaching and pre/post-observation interviews" (Park et al., 2011, p. 250). The PCK rubric was designed and theoretically grounded in the pentagon model of PCK as described by Park and Oliver (2008, p. 266). The PCK rubric was used to compile data regarding the alternate route science teacher's level of PCK development as recorded during the pre/post-interviews and observation notes. The multi-faceted nature of the classroom observations provided data to inform in what elements of their alternate route program learning experiences facilitated the development of their PCK.

Data Analysis

Data analyses focused on understanding participants' learning experiences in order to illustrate what, which, and how elements of their alternate route program promoted the development of their PCK. The interview notes, transcriptions, teacher-generated artifacts, and observations were coded in multiple cycles using a priori, descriptive, and pattern coding. A priori codes were generated from pedagogical content knowledge (PCK) components and subcomponents (Park & Oliver, 2008) as an indicator of teacher development. Park and Oliver's (2008) conception of PCK was used for this study, as they have designed several tools for collecting data about PCK, as well as techniques for analyzing the presence of PCK during observations and interviews.

The second cycle of coding was conducted using descriptive coding in order to concretely illuminate what was seen and heard during the interviews to identify lived experiences that were translated into classroom practice (Miles & Huberman, 1994; Saldaña, 2009). Codes were generated by organizing the interviewee answers and identifying repeating patterns in their answers. Pattern coding was used to identify patterns regarding which and how alternate route learning experiences were translated into practice. Codes were then clustered into themes to enable the merging of findings in order to generate assertions regarding which and how alternate route science teachers' learning experiences were translated into practice (Miles & Huberman, 1994; Stake, 2006). Being that case study serves to understand phenomena or relationships, categorical aggregation of the data throughout the study provided understanding of the case (Stake, 1995). As such, categorical aggregation of interviews through coding was used to understand which and how alternate route program learning experiences facilitated alternate route science teacher PCK development. By engaging in categorical aggregation, patterns emerged, which informed how alternate route science teachers translated their learning experiences into practice and how their learning experiences assisted in the development of their PCK. Since the goal of case study research is to understand behavior, issues, and context of the case, "the search for meaning often is a search for patterns" (Stake, 1995, p. 78).

Data interpretation of participant responses was viewed through the lenses of adult learning theory and sensemaking, in order to better understand and interpret the findings. Adult learning theory was used to understand alternate route science teachers' reflection of their own learning experiences and to understand which alternate route learning experiences were considered meaningful and relevant by the participants to result in a change to their PCK (Bransford et al., 1999). Sensemaking theory complemented adult learning theory in understanding how participants made sense of their alternate route learning experiences in their alternate route program so as to deepen understanding of which and how their learning experiences informed their PCK development (Weick et al., 2005; Weick, 2012). Shulman's theoretical framework on PCK was used as a means to categorize alternate route science teacher learning experiences to understand which and how participant learning experiences in the alternate route program promoted PCK development. By using the lenses of adult learning theory and sensemaking theory when analyzing and interpreting data that was collected and coded using Shulman's theoretical framework on PCK, patterns across participants were identified as to how participants' alternate route program learning experiences were perceived to promote their PCK development. Additionally, assertions were generated regarding an emerging theme as to when and how participant alternate route learning experiences informed their PCK development. Triangulation of interviews, observations, and teacher-generated artifacts was used to help cognize which and how alternate route program learning experiences were perceived by participants to inform their PCK development (Stake, 1995).

Findings

Findings reveal patterns among participant responses that participant alternate route program learned pedagogical experiences were not perceived to have attributed to participants' pedagogical content knowledge (PCK). Triangulation of data indicated that theme of *reflection* emerged as being necessary for the participants to translate learned experiences from their alternate route programs into classroom practice and subsequently promote development of their PCK. This section is organized based on common themes and subthemes that emerged.

Pedagogy

Findings under the theme of pedagogy centered on the alternate route program impact to participants' PCK development which included participant perceptions of PCK and the role PCK plays in science teaching. Additionally, findings regarding pedagogy focused on participants' definition of inquiry, their conception of science teaching, their understanding regarding the role of inquiry in science teaching and learning, and the level of inquiry observed during their classroom observation.

Program impact on PCK development. The majority of participant perceptions indicated no correlation between their alternate route course experiences and the development of their pedagogical content knowledge. For example, Table 11 demonstrates that Dana and Henry made connections to their alternate route learning experiences and teaching, but did not perceive that their alternate route courses directly facilitated the development of their PCK. Nancy indicated that she did not feel her alternate route program learning experiences informed her PCK. Nancy indicated that she felt her PCK development occurred as a result of an in-district induction program.

During the interviews and post-observation conferences, the participants indicated that their experiences in the classroom as a novice teacher proved most valuable to developing their PCK. Dana and Henry were the most forthright in asserting that classroom teaching experience has played a larger role in developing their PCK and informing their classroom practice than their alternate route program learning experiences. Nancy attributed her growth in PCK to the in-district induction program for new teachers. Dana indicated that, "A lot of it is more experienced-based when I learn something and then if I go back and revisit something from alternate route, then I'll start making the connection – ohh, that's what they were talking about." Henry responded that, "I really think mine is more by experience I am modifying and then maybe I'll go back and realize what they were trying to communicate to me later." Nancy indicated that, "I didn't even know what that word meant before teaching. So everything that I kind of know about it, I've learned through X [*the name of an in-district induction program for new teachers*]."

Table 11

Participant views of how AR learning experiences informed PCK

Participant	Participant Responses
Dana	They did talk about indirect and direct instruction so that would be something I think they kind of helped me with. Assessing students; there's been some good ideas on that I think that's floated around. The adolescent psychology, like kind of understanding where they are and that they're rebelling and how to kind of channel that positively. Those types of things have helped. But I do find a lot of the things in the alternate route class that they do recommend are really applicable for elementary settings or history and English settings and not so much science. So some of the tools they have in maps and worksheets are awesome but they would never, I could never figure out a way for them to apply here.
Nancy	Again, I don't think they have. Everything that I kind of know about it, I've learned through X [*the name of an in-district induction program for new teachers*].
Henry	I think that they've reinforced the ideas that I've kind of gathered so far. That this is kind of the background behind it. You know you can still formulate your own philosophy; you can still formulate the way you are going to run your classroom. But these are the people who kind of, you, know and these are the tactics, the ideas that have kind of led and paved the way so from there you know what do you resonate with? Are you into Danielson? Are you really going to kind of jump on that or do you do Bloom's taxonomy, are you going to Gardner's, you know and Pavlov. However, whoever you want to say, find what fits you and kind of turn that into your own. So, just definitely reinforcement of these ideas and kind of strategies.

Table 11 indicated that both AR programs offered courses that would include lessons to facilitate pedagogical content knowledge development in teachers, but all three participants did not attribute their growth to any of those offerings. All participants indicated that they found that personal experiences in the classroom informed their PCK development more than their alternate route program lessons.

Table 12 shows participants' responses regarding the role pedagogical content knowledge plays in their teaching based on their understanding of conceptions of PCK and the role it plays in their classroom instruction.

Table 12

AR science teacher understanding of the role of PCK in teaching

Participant	Participant Responses
Dana	In teaching science? Well, I think if you are talking about identifying where students can go wrong is something that would be key especially, we're learning the mole right now and just being able to rationalize that huge number of particles 6.02×10^{23} is really difficult for students, but it's something that I didn't know until I walked into it really. So, next year, I will know, hey, I know that I need to spend more time on this because this is something difficult for students to get. That's really more experienced-based in my opinion. I try to use the textbook as hints. The teacher's edition has common misconceptions and I try to make sure that I review those, but sometimes some of those questions that I get in the class, they are just nowhere close to what the textbook might say the common misconceptions are going to be.
Nancy	I think it's a way of structuring how you want the students to think about it and kind of get them to that higher level thinking. So we start with the basics: what, when, where, why, and we make them apply it, analyze it, come to a conclusion.
Henry	Well I think you need to know how your students learn and be able to relate to your students and understand that not one size fits all. Um, obviously you need to know the things you are teaching to the kids for… I mean… I think… I don't know how to say it. Obviously you need to know your stuff before you can go on and tell someone else, at the same time you need to know that maybe student A learns better visually where student B you need to hear it auditorily or student C needs to see it in actuality, like an experiment or something. So just understanding that even though science is pretty cut and dry, there are different ways to approach it for

	your students.

All three participants spoke to components of PCK regarding knowledge of students and student understanding of content. Dana spoke specifically about understanding where students encounter difficulty with abstract concepts based on classroom experiences, as well as being aware of and addressing common student misconceptions. Nancy spoke of scaffolding the learning to engage the students in higher level thinking. Henry spoke about knowing the content, as well as how the various students in his class learn to best address their learning needs.

Although all three participants defined PCK in very different ways (see Table 12), analysis of PCK rubric scores (see Table 13) indicated that participants' PCK fell primarily in the limited or basic understanding of PCK elements, with several elements for each participant falling within the proficient range. The PCK disaggregated level of performance rubric score for Dana was 1.9, for Nancy was 2.3, and for Henry was 2.4. The maximum disaggregated PCK rubric score is a four. As such, the scores indicate that Dana exhibited limited level of PCK, while Nancy and Henry exhibited a basic level of PCK during the scheduled classroom observation.

Table 13

PCK rubric scores for the participants

Participant	**Dana**	**Nancy**	**Henry**
Participant Raw Score	17/36	21/36	22/36
Participant Percentages	47%	58%	61%
Level of Performance	1.9	2.4	2.3

Adult Learning and Sensemaking

By looking at the data through the lenses of adult learning theory and sensemaking theory, this study generated an understanding of how alternate route science teacher alternate route program learning experiences facilitated their PCK development. Since learning is an active process of using new knowledge to build upon prior knowledge and involves a process of change when situated in meaningful and relevant contexts (Bransford et al., 1999), looking through the lens of adult learning theory generated an understanding of how alternate route science teachers' PCK developed, as evidenced by how alternate route science teachers translated their alternate route program learning experiences into classroom practice. Looking through the lens of adult learning theory also helped discern the particular alternate route program learning experiences that participants perceived to promote their PCK development.

The lens of sensemaking theory helped inform assertions regarding how alternate route science teachers made sense of their adult learning, in order to develop their PCK. In addition, sensemaking theory helped make visible the means by which alternate route science teachers' made sense of their learning in their alternate route programs, the connections alternate route science teachers made between their alternate route program learning experiences and their classroom practice, as well as how sensemaking assisted alternate route science teachers in the development of their PCK. Additionally, as a researcher conducting a case study, interpretations are built upon making new meanings and making sense of observations, to generate understanding of the experiences of alternate route science teachers (Stake, 1995).

Analysis of Findings

The theme of reflection emerged as a result of triangulation of findings of data sources. Reflection indicated how the participants actively thought about their alternate route program learning and its pertinence to their classroom practice, how they carefully considered ways in which their alternate route program learning could positively impact their classroom instruction.

Reflection

Reflection was observed to be important in alternate route science teachers' learning experiences promoting the development of their pedagogical content knowledge. The theme of reflection emerged as participants indicated that they needed to have time to reflect on their teaching practice in order to develop their PCK. Participants had the opportunity to reflect during their alternate route courses as per program course descriptions, but when asked about reflective practice, participants indicated that they did not reflect. For instance, participant responses indicated that there was a lack of active reflection of the teaching practices in their alternate route learning experiences and in effect, participants felt that their alternate route learning experiences did not inform the development of their own PCK. As evidenced by participant responses in Table 14, active and ongoing reflection seems to be necessary in order to facilitate the development of alternate route science teachers' PCK.

Dana and Henry both spoke about going back and revisiting or realizing connections to their alternate route learning experiences, in combination with their classroom experience, as being a means by which reflection promoted the development of their PCK.

Table 14

Responses speaking to the role of reflection in PCK development

Participant	Participant Responses
Dana	A lot of it is more experienced-based when I learn something and then if I go back and revisit something from alternate route, *then I'll start making the connection – ohh, that's what they were talking about* [emphasis added]. Chunking is probably a really good example of that and differentiated instruction. I read about it, I wrote about it, I researched about it, but I never really understood how to implement it. When I did the lab and was actually able to chunk it successfully, then *that's when I was able to make the connection* [emphasis added].
Henry	I really think mine is more by experience. *I am modifying and then maybe I'll go back and realize what they were trying to communicate to me later* [emphasis added]. Yeah, I don't know that, I mean I've tried to do some things, like with inquiry, like have the students try to discover things on their own, but it actually I didn't find it so successful, especially in science, I find direct instruction a lot more successful than that. *So it might be another one when one day when I find it* [emphasis added].

Nancy did not speak about reflection in her responses. In fact, Nancy scored low on the rubric for reflection and her responses to interview and post-observation conference questions indicated that she did not perceive her alternate route learning experiences informed the development of her PCK.

Additionally, in response to an interview question regarding which alternate route program learning experiences helped her in the classroom and why, Dana noted, "maybe I'll go back and realize what they were trying to communicate to me later." Dana was invited in the alternate route program to write about what she reads and she saw that as an exercise in writing a research paper, as opposed to an opportunity to reflect and/or apply her learning. Moreover, comment such as "so I never really thought to keep the end goal in mind," "I could never figure out a way for them to apply here," and "I feel like it's a lot of projects and right now as a first year and as someone who wasn't traditionally trained, everything is on the fly and experienced-based. You kind of feel you're drowning with the amount of work that they give you" show how Dana is invited in the alternate route program to reflect and apply her alternate route program learning but she struggled to do so. The last comment alludes to the lack of time Dana felt she had to reflect on her learning.

For Nancy, time emerged as a reason why she did not engage in reflection about her alternate route learning. This became apparent in her response to being able to take advantage of professional development opportunities where she stated, "I felt like I didn't have the extra time, just between the alternate route and teaching. I didn't have extra time." Furthermore, comments such as "I have to learn their way and do their assignments their way then not apply any of that to the way I actually do things," as well as "It's a lot of what I would call, and my students would call, busy work. You know, read this article and tell me what you think. Or watch this documentary and tell me what you think" and "For the most part I find it not helpful … I do it because I have to" show how Nancy was invited in her alternate route program to reflect and apply her learning yet she did not realize the opportunity to reflect and apply.

Although Henry's alternate route program description cited multiple reflection assignments, Henry's responses spoke to specific activities that he was asked to complete for his alternate route program, not to being invited to reflect. These assignments did not encourage or afford Henry to opportunity to reflect on how his alternate route learning translated to his classroom teaching. For instance, a response to an interview question which focused on his alternate route program learning experiences that helped inform his

PCK, Henry indicated that his learning to inform his PCK did not come from his alternate route program:

> "I think that they've reinforced the ideas that I've kind of gathered so far. That this is kind of the background behind it. *You know you can still formulate your own philosophy; you can still formulate the way you are going to run your classroom* [emphasis added]. But these are the people who kind of, you, know and these are the tactics, the ideas that have kind of led and paved the way so from there you know what do you resonate with? Are you into Danielson? Are you really going to kind of jump on that or do you do Bloom's taxonomy, are you going to Gardner's, you know and Pavlov. However, whoever you want to say, *find what fits you and kind of turn that into your own* [emphasis added]. So, just definitely reinforcement of these ideas and kind of strategies."

Time for reflection was another aspect that Henry alluded to:

> "I think it gets better with, you know, having a year under my belt lesson planning and kind of not knowing what it's going to be like in class. And I mean in the summer I'm literally going to take my entire lesson plans for all the units and kind of redo them and make the adjustments I need to make."

Based on participant understanding of the role of reflection in promoting their PCK, as well as the low PCK rubric scores, reflection emerged as a component necessary in the development of alternate route science teachers' PCK. Additionally, the lack of reflection being mentioned in the data is indicative of the role that reflection could play in promoting translation of alternate route learning to classroom practice, and subsequently, PCK development. The participants were not reflecting on their alternate route learning, even when asked to do so in their alternate route program. More research regarding the role of reflection in PCK development of first year alternate route teachers is warranted to tease out the complex role reflection plays in PCK development.

Discussion and Implications

In accordance with prior research, findings from this study demonstrate that there exist problems for first year teachers specifically in their ability to translate pedagogical practices learned into their classroom practice (Darling-Hammond et al., 2001). Alternate route science teachers found difficulty in finding and making time for the reflection required to modify their instructional strategies as a result of engaging in their alternate route program learning experiences. Participants indicated that day to day the responsibilities of teaching, in conjunction with transitioning to a new career (teaching), afforded them little to no time to reflect upon their learning.

Sensemaking and Adult Learning for PCK Development

A component to successful sensemaking by the participants was having time to reflect on their alternate route learning in order to make sense of it and apply the learning to their practice. This theme of reflection emerged from the data when looking at responses about the lack of connection between alternate route program learning and the science classroom, references to the lack of required application of their learning, as well as participant comments regarding the lack of time to process information due to the alternate route program course load and the workload of a first year teacher. Since alternate route science teachers do not have the teaching experiences from which to develop their ideas and skills for masterful teaching in the classroom, and since "contemporary learning theory recognizes the role that both experience and reflection play in the development of ideas and skills" (Darling-Hammond et al., 2001, p. 9), it is not surprising that alternate route teachers had difficulty making sense of their alternate route learning during their first year of teaching. As such, a key feature to alternate route science teacher sensemaking of their alternate route program learning experiences would be to provide intentional time for reflection of learned experiences when formulating new ideas for teaching.

A connection between sensemaking of learning promoted by reflection and PCK development is supported indirectly by Shannon's (2006) findings from his multi-method case study of four chemistry teachers' decision-making during the planning, teaching, and reflection stages of their practice to determine PCK's influence for the topic of chemical equilibrium. Shannon found that "teachers with less teaching experience displayed a model of PCK characterized by an underdeveloped and sometimes fragmented understanding of the topic as well as a fragile knowledge of student understanding" (p. 8).

For teachers, integrating theory into practice to modify their instruction and develop their PCK is an iterative process of evaluating specific classroom situations, student interactions with the content, and determining when and how to use their professional learning experiences to inform a change in practice (Darling-Hammond et al., 2001; van Driel, Verloop, & De Vos, 1998; van Driel, De Jong, & Verloop, 2002). In addition, adult learning is a cycle promoted through purposeful design of a learning environment that progresses through invitation to learn, or engagement, to experience, to *reflection* (emphasis added) and evaluation (Loucks-Horsley et al., 2010). The lack of reference to reflection in the data suggests that participants are missing a component of the adult learning cycle, a component that if not completed, can lead to diminished learning.

The participants in this study were in the beginning stages of this iterative process and would benefit from ongoing support for reflection in an intentional, purposeful manner would support their PCK development. Moreover, promoting the adult learning cycle with purposeful intent to develop first year alternate route science teacher translation of alternate route learning to practice in an intentional, purposeful manner would support their PCK development.

Park and Oliver (2008) identified that PCK development incorporates knowledge acquisition and knowledge use, such that teachers develop PCK through a dynamic relationship between knowledge acquisition, new applications of that knowledge, and reflection on the uses of that knowledge in practice. Park and Oliver (2008) found that teachers produce PCK through their own teaching experiences and the most powerful changes to their PCK are a result of these experiences in practice. The responses from the participants in this study support and are supported by the findings of Park and Oliver (2008). Participant responses to interview questions that specifically asked teachers to explain the role of PCK in science teaching identified knowledge of students, knowledge of where students are in the learning process, as well as the teacher's role in structuring the classroom learning experience for the students to meet the students' learning needs. Dana focused on student misconceptions in her answer, Henry on multiple learning styles in the classroom, and Nancy on scaffolding instruction to promote higher order thinking by the students. Responses also indicated that participants felt their classroom experiences as teachers provided them great insight to developing their PCK than their alternate route learning. This finding is also supported by the work of van Driel, de Jong, and de Vos (2002) who determined that teachers' PCK growth was influenced mostly by their teaching experiences. As the participants did not engage in ongoing reflection regarding the uses of their alternate route learning in practice, reflection was a missing element in developing their PCK.

PCK rubric scores to measure PCK level during the observation and pre/post-interviews identified participants as falling within the limited or basic understanding of the PCK components of planning, implementation, and reflection. PCK rubric scores were in alignment with participant responses regarding the lack of PCK development as a result of alternate route learning. As the participants did not engage in intentional and purposeful reflection about how their alternate route learning could be applied to practice, it is not surprising that participants scored lower on the PCK rubric. One would expect new teachers to be in the initial stages of PCK development and without concerted reflection on the relationship between new knowledge and application to their teaching, classroom teaching experiences become the primary means for their PCK development.

These findings lead to an understanding that educational leaders can support the development of alternate route science teachers' PCK by providing a developmental continuum of professional learning experiences which promote sensemaking, reflection, and subsequently promote PCK development in these teachers (Huebner, 2009).

Triangulation of data sources indicated that first year alternate route science teachers did not perceive their alternate route learning experiences as informing the development of their PCK. Responses and the theme that emerged from the data indicated that reflection on teaching and learning was necessary for the development of their PCK.

Implications for Practice

Historically, alternate route programs were one means to increase the number of science teachers in the teaching pool. In addition, it is important for educational institutions and administrators who support science teacher development to better understand how alternate route science teachers develop their pedagogy as teachers.

Further knowledge of what, which, and how alternate route science teachers' learning experiences foster the development of their PCK can inform which professional learning opportunities are offered or required to support their development as teachers. Identifying the learning experiences foster PCK development in alternate route science teachers can assist those who support alternate route science teachers in designing learning experiences to promote the development of alternate route science teachers, and in turn, promote student achievement.

As such, the findings from this study suggest that first year alternate route science teachers needed time for reflection to see the connection between their alternate route leaning and their practice and time to actually revise and/or intentionally plan lessons in alignment with alternate route learning. Participants lamented that they could not find the time to apply their learning due to the demands of being a first year teacher and their lack of time.

Even though the participants were invited to reflect during interviews, post-observation conferences, and their alternate route program learning, the lack of participant reflection in the data indicates that supporters of alternate route science teachers need to provide alternate route science teachers strategic and intentional opportunities to reflect on their learning and the application of their learning to their classroom practice. Alternate route science teachers might well benefit from guided and modeled reflection during the alternate route program, as well as with their mentor in the school where they teach. The findings from this study are supported by Ripley (2010) who identified that teacher effectiveness was increased by how teachers learn to analyze their practice.

In accordance, participants in alternate route programs would benefit from intentional and implicit connections between learning and practice being made by alternate route program directors and/or instructors. Time for reflection and application of their learning to their practice could be infused into the alternate route program. Principals, supervisors, and mentors who support alternate route science teachers during their first year of teaching can help first year alternate route science teachers by engaging them in conversations regarding the application of their alternate route learning to practice, as well as by helping these teachers to make connections between their alternate route learning and their teaching responsibilities. In addition, first year teachers would benefit from specific PCK professional development and time to practice application of their new learning.

The findings from this study are supported by Leithwood and Jantzi's (2006) assertion that "there is a significant gulf between classroom practices that are 'changed' and practices that actually lead to greater pupil learning; the potency for leadership for increasing student learning hinges on the specific classroom practices that leaders stimulate, encourage and promote" (p. 223). For alternate route science teachers to apply their learning to their practice, alternate route programs and district leaders need to assist these new teachers in making sense of their alternate route learning, in reflecting on their new learning, as well as its application to their instruction.

Furthermore, understanding how alternate route science teachers' alternate route program learning experiences inform their classroom practice and how these learning experiences help promote PCK development in alternate route science teachers will assist supervisors, principals, and districts in building the capacity of alternate route teachers to improve student learning in science. Understanding how to assist alternate route science teachers in developing into effective teachers is critical as it can positively impact student literacy.

Implications for Policy

Policy decisions regarding supporting alternate route science teachers during their first years of teaching can be aided by understanding the role reflection plays in how alternate science teachers' alternate route program learned experiences translate into classroom practice (Feistritzer, 2009; Grossman & Loeb, 2010; Kee, 2012). By understanding which and how alternate route science teachers' alternate route program learned experiences facilitate their PCK development, this research can inform policy surrounding alternate route programs and the learning experiences they provide to support and promote alternate route teacher development and effectiveness. Likewise, findings from this research could inform policy surrounding the design of learning experiences for traditional route teacher preparation programs.

As such, findings from this study suggest that alternate route teachers would benefit from alternate route programs examining their programs for the course offerings and progression of courses offered in order to intentionally structure their program to be in alignment with the teaching responsibilities of the participants. By doing so, intentional and purposeful reflection of the connection between coursework and practice may promote PCK development. Additionally, alternate route programs would benefit from examining their courses for modeled, practiced, and intentional opportunities for reflection that results in actionable changes to the classroom practice of alternate route teachers.

Alternate route programs may better serve alternate route teachers by engaging them in routine and practiced reflection. For example, the policy of engaging K-12 teachers at the same time for all of the alternate route courses may need to be re-evaluated, as this policy can hamper participants' ability to reflect on their alternate route learning in order to apply it to their classroom practice. Additionally, extending the alternate route program to be a two year program and/or requiring additional clinical experiences before full time teaching could be considered to provide sustained support for alternate route teachers.

Since the alternate route program is the means by which alternate route science teachers attain their pedagogical knowledge for teaching, reflecting on the relevancy and application of new learning in order to translate this learning into practice adds to the literature surrounding science education pedagogy (Keeley, 2005; Loucks-Horsley et al., 2010; Mundry et al., 2010).

Implications for Research

Further research can look into comparing elements within traditional and alternate route programs and how such elements can be modified to better address the development of teachers within such programs. Some future research questions that can be generated from such findings include: (a) What existing elements within traditional and alternate route programs help teachers develop certain aspects of their PCK? (b) What existing policies help in the growth and development of teacher PCK? (c) What professional development within district is most beneficial to novice alternate route teachers? (d) How does the amount of time for teacher reflection on their learning inform their PCK development? It is anticipated that sharing the findings of this study can afford an opportunity for discussion regarding the effectiveness of such programs in light of the demand for quality science teachers.

More research is needed to tease out the particulars of how certification programs translate to teacher effectiveness. Conflicting research indicates that teacher effectiveness of alternate route teachers is dependent upon the alternate route program, as well as the support the alternate route teacher receives from the district in which the teacher is hired (Humphrey & Wechsler, 2007; Humphrey, Wechsler, & Hough, 2008). Alternate route programs have been found to be less effective at preparing and retaining recruits than university-based traditional teacher preparatory programs (Darling-Hammond, 2000). Alternatively, alternate route programs that require substantial pedagogical training, mentoring and evaluation similar to traditional university-based preparatory programs have been found to produce effective teachers (Wilson, Floden, & Ferrini-Mundy, 2001).

For science teachers to be effective in the classroom, they must have knowledge about science learners, curriculum, instructional strategies, and assessment through which they can transform their knowledge of science into effective teaching and subsequent learning by their students (Abell, Rogers, Hanuscin, Lee, & Gagnon, 2009). Park and

Oliver (2008) found that teachers develop PCK through a dynamic relationship between knowledge acquisition, new applications of that knowledge, and *reflection* [emphasis added] on the uses of that knowledge in practice. Moreover, contemporary learning theory recognizes that reflection plays a role in the development of ideas and skills (Darling-Hammond et al., 2001). Beauchamp's (2015) review of the literature regarding reflection in teacher education identified that teacher educators have not provided clarity on the meaning of reflection and have not modeled the practice of reflection. Additionally, Beauchamp (2015) speaks to the importance of context for reflection being necessary for teacher education, which is in keeping with the findings of this study that teachers need to find relevancy to their learning in order to change their practice as a result of their learning. As such, more research is needed about ways to engage alternate route teachers in reflection regarding their alternate route learning and application to classroom practice. Additionally, more research is needed on how novice and alternate route teachers can benefit from ongoing, intentional reflection.

Conclusion

This case study researched lived and extended learning experiences of alternate route science teachers to understand which and how learning experiences from their alternate route programs facilitated their PCK development.

Findings from this study indicate that participants did not significantly develop their PCK as a result of their alternate route learning. Participants identified that they were unable to connect much of their coursework to their practice. Reflection seems to play a pivotal role in promoting PCK. Future research should emphasize how programmatic changes in alternate route programs can incorporate reflection to achieve more vivid learned experiences for alternate route teachers and therefore inform alternate route teacher practices and program policies that best promote teacher development. Continued research is necessary to tease out the elements of alternate route programs, as well as traditional teacher preparation programs, which best promote teacher development.

References

Abell, S. K. (2007). Research on science teacher knowledge. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 1105–1149). Mahwah, NJ: Lawrence Erlbaum.

Abell, S. K., Rogers, M. A. P., Hanuscin, D. L., Lee, M. H., & Gagnon, M. J. (2009). Preparing the next generation of science teacher educators: A model for developing PCK for science teachers. *Journal of Science Teacher Education, 20*(1), 77–93. doi 10.1007/s10972-008-9115-6

Ahern, K. J. (1999). Ten tips for reflexive bracketing. *Qualitative Health Research, 9*(3), 407-411.

Allen, C. D., & Penuel, W. R. (2015). Studying teachers' sensemaking to investigate teachers' responses to professional development focused on new standards. *Journal of Teacher Education, 66*(2), 136-149.

American Association for the Advancement of Science. (1990). *Science for all Americans*. NewYork: Oxford University Press.

Argyris, C., & Schön, D. D. (1974). *Theory in Practice: Increasing Professional Effectiveness* (2nd ed.). San Francisco, CA: Jossey Bass.

Auerbach, C. F., & Silverstein, L. B. (2003). *Qualitative data: An introduction to coding and analysis.* New York, NY: New York University Press.

Ayres, L. (2008). Semi-structured interview. In L. M. Given (Ed.), *The SAGE encyclopedia of qualitative research methods* (pp. 811-812). Thousand Oaks, CA: Sage Publications, Inc. doi: 10.4135/9781412963909.n420

Babu, S., & Mendro, R. (2003, April). *Teacher accountability: HLM-based teacher effectiveness indices in the investigation of teacher effects on student achievement in a state assessment program*, Paper presented at the American Educational Research Association Annual Meeting, Chicago, IL. Retrieved from http://www.dallasisd.org/cms/lib/TX01001475/Centricity/Shared/evalacct/research/articles/Babu-Teacher-Accountability-HLM-Based-Teacher-Effectiveness-Indices-2003.pdf

Barber, M., & Mourshed, M. (2007). *How the world's best-performing school systems come out on top*. London: McKinsey & Company. Retrieved from http://www.smhc-cpre.org/wp-content/uploads/2008/07/how-the-worlds-best-performing-school-systems-come-out-on-top-sept-072.pdf

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M., & Tsai, Y-M. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. *American Educational Research Journal, 47*(1), 133-180. doi: 10.3102/0002831209345157

Beauchamp, C. (2015). Reflection in teacher education: Issues emerging from a review of current literature. *Reflective Practice, 16*(1), 123-141. doi:10.1080/14623943.2014.982525

Berry, B. (2010, May). Strengthening state teacher licensure standards to advance teaching effectiveness. American Association of Colleges for Teacher Education & National Education Association. *Policy Brief*.

Berry, B., Daughtrey, A., & Wieder, A. (2010, March). *Teacher effectiveness: The conditions that matter most and a look to the future*. Hillsborough, NC: Center for Teacher Quality. Retrieved from http://www.ncsl.org/portals/1/documents/Educ/2010EdFinMtgBerry-Daughtrey-Wieder.pdf

Birkeland, S. E., & Peske, H. G. (2004). *Literature Review of Research on Alternative Certification.* National Education Association, Washington, DC. Retrieved from http://www.teach-now.org/NEAFullText.pdf.

Borg, S. (2001). The research journal: A tool for promoting and understanding researcher development. *Language Teaching Research, 5*(2), 156-177.

Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J. (2006). How changes in entry requirements alter the teacher workforce and affect student achievement. *Education Finance and Policy, 1*(2), 176-216.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school.* Washington, DC: The National Academies Press.

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics, 112*: 3–11. doi: 10.1111/j.1949-8594.2011.00109.x

Bricker, L. A., & Bell, P. (2008). Conceptualizations of argumentation from science studies and the learning sciences and their implications for the practices of science education. *Science Education*, *92*(3), 473-498.

Brodsky, A. E. (2008). Fieldnotes. In L. M. Given (Ed.), *The SAGE encyclopedia of qualitative research methods* (pp. 811-812). Thousand Oaks, CA: Sage Publications, Inc. doi: 10.4135/9781412963909.n172

Carey, K. (2004). The real value of teachers: Using new information about teacher effectiveness to close the achievement gap. *Thinking K-16, 8*(1), 3-32. Retrieved from http://www.cgp.upenn.edu/pdf/Ed%20Trust.pdf

Certificate Subject Area/Grade Level and Codes. (n.d.). Retrieved August 30, 2014, from http://www.state.nj.us/cgi-bin/education/license/endorsement.pl?string=999&maxhits=1000&field=2

Cochran-Smith, M., & Power, C. (2010). New directions for teacher preparation. *Educational Leadership, 67*(8), 6-13.

Common Core State Standards Initiative. (2011). *The Standards: English language arts standards*. Retrieved from http://www.corestandards.org/the-standards/english-language-arts-standards/

Constantine, J., Player, D., Silva, T., Hallgren, K., Grider, M., & Deke, J. (2009). *An evaluation of teachers trained through different routes to certification, Final Report* (NCEE 2009-4043). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Corcoran, S. P., & Jennings, J. L. (2009). *Review of "An evaluation of teachers trained through different routes to certification: Final report."* Boulder, CO and Tempe, AZ: Education and the Public Interest Center & Education Policy Research Unit. Retrieved from http://nepc.colorado.edu/thinktank/review-evaluation-of-teachers

Coyne, I. T. (1997). Sampling in qualitative research: Purposeful and theoretical sampling; merging or clear boundaries? *Journal of Advanced Nursing, 26*(3), 623-630.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches*. (2nd ed). Thousand Oaks, CA: Sage.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. (3rd ed). Los Angeles, CA: Sage.

Danielson, C. (2007). *Enhancing professional practice: A framework for teaching*. (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Darling-Hammond, L. (1999). *Teaching quality and student achievement: A review of state policy evidence*. Center for the Study of Teaching and Policy, University of Washington, Seattle, WA.

Darling-Hammond, L. (2000). How teacher education matters. *Journal of Teacher Education,51*(3), 166-173. doi:10.1177/0022487100051003002

Darling-Hammond, L. (2009). Educational opportunity and alternative certification: New evidence and new questions. *Stanford Center for Opportunity Policy in Education, 1*, 1-12. Retrieved from http://edpolicy.stanford.edu/sites/default/files/publications/educational-opportunity-and-alternative-certification-new-evidence-and-new-questions.pdf

Darling-Hammond, L. (2010). Teacher education and the American future. *Journal of Teacher Education, 61*(1-2), 35-47. doi: 10.1177/0022487109348024

Darling-Hammond, L., Austin, K., Orcutt, S., & Rosso, J. (2001). *Episode #1: Introduction Chapter: How people learn: Introduction to Learning Theories*.

From the learning classroom: Theory into practice: A telecourse for teacher education and professional development, 1-21.

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad.* Dallas, TX. National Staff Development Council.

Davis, E. A. (2003). Knowledge integration in science teaching: Analyzing teachers' knowledge development. *Research in Science Education, 34,* 21-53.

De Jong, O., Van Driel, J., & Verloop, N. (2005). Preservice teachers' pedagogical content knowledge of using particle models in teaching chemistry. *Journal of Research in Science Teaching, 42,* 947-964.

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The discipline and practice of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (pp. 1-19). Thousand Oaks, CA: Sage Publications, Inc.

Duncan, B. R. (2013). *A case study of alternatively trained science teachers: Attainment of pedagogical content knowledge.* (Doctoral Dissertation, Tennessee State University). Available from *ProQuest Dissertations and Theses database. (*Order No. 3599426). Retrieved from http://ezproxy.rowan.edu/login?url=http://search.proquest.com/docview/1462054093?accountid=13605. (1462054093).

Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (Eds.). (2007). *Taking science to school: Learning and teaching science in grades K-8.* Washington, DC: National Academies Press.

Educational Testing Service. (2014). *ETS: The praxis series: For test takers*. Retrieved from https://www.ets.org/praxis/about/

Epstein, N. (2004). *Who's in charge here? The tangled web of school governance and policy.* Washington, D.C.: Brookings Institution Press.

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

Feistritzer, C. E. (2009). Teaching while learning: Alternate routes fill gap. *EDge, 5*(2), 3-15.

Ferguson P., & Womack, S. T. (1993). The impact of subject matter and education coursework on teaching performance. *Journal of Teacher Education, 44*(1), 55-63.

Fowler, F. C. (2009). Power and education policy. *Policy studies for educational leaders: An introduction*. (3rd ed.). Upper Saddle River: Prentice Hall.

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.

Glesne, C. (2006). Becoming qualitative researchers. Boston, MA: Pearson.

Glynn, S. M., & Koballa, T. R. (2005). The contextual teaching and learning instructional approach. In Yager, R. E. (Ed.), *Exemplary science: Best practices in professional development* (75-84). Arlington, VA: NSTA Press.

Goldhaber, D., & Brewer, D. (1996). Evaluating the effect of teacher degree level on educational performance. In W. Fowler (Ed.), *Developments in School Finance*, (pp. 199–210). Washington, DC: U.S. Department of Education, National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubs97/97535l.pdf

Goldhaber, D., & Brewer, D. (1999). Teacher Licensing and Student Achievement. In M. Kanstoroom & C. E. Finn, Jr (Eds.), *Better Teachers, Better Schools* (pp. 83-102). Washington, DC: The Thomas B. Fordham Foundation.

Goldhaber, D., & Brewer, D. (2000). Does teacher certification matter? High school teacher certification status and student achievement. *Educational Evaluation and Policy Analysis, 22*(2), 129-145.

Gordon, R., Kane, T. J., & Staiger, D. O. (2006). *Identifying effective teachers using performance on the job*. The Brooking Institution.

Greenlee, B., & Brown, J. J., Jr. (2009). Retaining teachers in challenging schools. *Education, 130*(1), 96-109.

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.

Grossman, P., & Loeb, S. (2010). Learning from multiple routes. *Educational Leadership, 67*(8), 22-27.

Gusky, T. R. (2002). Does it make a difference? Evaluating professional development. *Educational Leadership, 59*(6), 45-51.

Hand, B., Norton-Meier, L., Staker, J., & Bintz, J. (2009). *Negotiating science: The critical role of argument in student inquiry*. Portsmouth, NH: Heinemann.

Hanna, P., & Gimbert, B. (2011). Falling flat: Certification as an insufficient indicator of teacher quality. *Journal of the National Association for Alternative Certification, 6*(2), 31-52.

Hanushek, E. A. (2002). Teacher quality. In L. T. Izumi and W. M. Evers (Eds.), *Teacher quality* (pp. 1–12). Stanford, CA: Hoover Press. Retrieved from http://hanushek.stanford.edu/sites/default/files/publications/Hanushek%202002%20Teacher%20Quality.pdf

Harris, D. N., & Sass, T. R. (2011). Teacher training, teacher quality and student achievement. *Journal of Public Economics, 95*(7), p. 798-812.

Hatch, J. A. (2002). *Doing qualitative research in education settings.* Albany: SUNY Press.

Hattie, J. (2009). Visible learning: A synthesis of over 800 meta-analyses relating to achievement. New York: Routledge.

Hodder, I. (1994).The interpretation of documents and material culture. In N. K. Denzin and Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 393-494). Thousand Oaks, CA: SAGE.

Huebner, T. (2009). What research says about…/The continuum of teacher learning. *Educational Leadership, 66*(5), 88-91.

Huff Post Education. (2011, May 25). U.S. falls in world education rankings, rated "average." Retrieved from http://www.huffingtonpost.com/2010/12/07/us-falls-in-world-education-rankings_n_793185.html

Humphrey, D. C., & Wechsler, M. E. (2007). Insights into alternative certification: Initial findings from a national study. *Teachers College Record, 109*(3), 483-530. Retrieved from http://www.sri.com/sites/default/files/publications/insights-alt-cert-initial-findings.pdf

Humphrey, D. C., Wechsler, M. E., & Hough, H. (2008). Characteristics of effective alternative teacher certification programs. *Teachers College Record, 110*(1), 1-63. Retrieved from http://www.sri.com/sites/default/files/publications/effective-alt-cert-programs-characteristics.pdf

Ingersoll, R. M. (2003). *Out-of-field teaching and the limits of teacher policy.* Seattle: Center for the Study of Teaching and Policy, University of Washington.

Ingersoll, R. (2006). *Understanding supply and demand among mathematics and science teachers*. In Rhoton, J., & Shane, P. (Eds.). *Teaching and Science in the 21st century*. Arlington, VA: NSTA Press.

Ingersoll, R., Merrill, L., & May, H. (2012). Retaining teachers: How preparation matters. *Educational Leadership, 69*(8), 30-34.

Ingersoll, R., & Perda, D. (2010). Is the supply of mathematics and science teachers sufficient? *American Education Research Journal, 47*(3), 563-594. doi: 10.3012/0002831210370711

Issacs, M. L., Elliott, E. M., McConney, A., Wachholz, P., Greene, P., & Greene, M. (2007). Evaluating "quality" methods of filling the "teacher gap": Results of a pilot study with early career teachers. *Journal of the National Association for Alternative Certification, 2*(2), 5-22. Retrieved from http://www.jnaac.com/index.php/test/article/view/49/37

Janesick, V. J. (1999). A journal about journal writing as a qualitative research technique: History, issues, and reflections. *Qualitative Inquiry, 5*(4), 505-524.

Jarvis, P. (2010). *Adult education and lifelong learning: Theory and practice.* (4th ed.). New York, NY: RoutledgeFalmer.

Johnson, S. M., Birkeland, S. E., & Peske, H. G. (2005). Life in the fast track: How states seek to balance incentives and quality in alternative teacher certification programs. *Educational Policy, 19*(1), 63-89.

Kane, T. E., Rockoff, J. E., & Staiger, D. O. (2006, March). *What does certification tell us about teacher effectiveness? Evidence from New York City.* Working Paper 11844. Cambridge, MA: National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w12155.pdf?new_window=1

Kee, A. N. (2012). Feelings of preparedness among alternatively certified teachers: What is the role of program features? *Journal of Teacher Education 63*(23), 23-38. doi: 10.1177/0022487111421933

Keeley, P. (2005). *Science curriculum topic study: Bridging the gap between standards and practice.* Thousand Oaks, CA: Corwin.

Keeley, P., & Rose, C. (2006). *Mathematics curriculum topic study: Bridging the gap between standards and practice.* Thousand Oaks, CA: Corwin.

Killion, J. (2002). *Assessing impact: Evaluating staff development*. Oxford, OH: National Staff Development Council.

Killion, J., & Hirsch, S. (2011). The elements of effective teaching. *Journal of Staff Development*, *32*(6), 10-16.

Klagholz, L. (n.d.). *New Jersey's Alternate Route to Teacher Certification*. Retrieved from http://www.pearsonassessments.com/hai/images/NES_Publications/2002_12Klagholz_340_1.pdf

Klagholz, L. (2000). Growing better teachers in the garden state: New Jersey's "alternate route" to teacher certification. Washongton, DC: Thomas B. Fordham Foundation. Retrieved from http://www.edexcellencemedia.net/publications/2000/200001_growingbetterteachers/klagholz.pdf

Knowles, M., Holton, E. F., & Swanson, R. A. (2000). *The adult learner: The definitive classic in adult education and human resource development*. Houston, TX: Gulf.

Kreider, H. (Ed.). (2006). The evaluation exchange. *Harvard Family Research Project Harvard Graduate School of Education*, *11*(4), 1-24.

Leithwood, K., & Jantzi, D. (2006). Transformational school leadership for large-scale reform: Effects on students, teachers, and their classroom practices. School Effectiveness and School Improvement, 202-227.

Leithwood, K., Louis, K. S., Anderson, S., & Wahlstrom, K. (2004). *How leadership influences student learning: Review of research.* Minneapolis, MN: University of Minnesota, Center for Applied Research and Educational Improvement.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Beverly Hills, CA: Sage.

Loucks-Horsley, S., Stiles, K. E., Mundry, S., Love, N., & Hewson, P. W. (2010). *Designing professional development for teachers of science and mathematics*. (3^{rd} ed.). Thousand Oaks, CA: Corwin.

Loughran, J., Mulhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching, 41*(4), 370-391.

Ludlow, C. (2011). Alternative certification pathways: Filling a gap? *Education and Urban Society, 45*(4), 440-458. doi: 10.1177/0013124511413916

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95–132). Boston: Kluwer.

Marshall, C., & Rossman, G. B. (2011). Managing, analyzing and interpreting data. In C. Marshall & G. B. Rossman (Eds.), *Designing qualitative research* (5^{th} ed., pp. 205-222), Thousand Oaks, CA: SAGE Publishers. Retrieved from http://www.sagepub.com/upm-data/33907_Chapter8.pdf

Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement.* Alexandria, VA: Association for Supervision and Curriculum Development.

McKechnie, L. E. F. (2008). Observational Research. In L. M. Given (Ed.), *The SAGE encyclopedia of qualitative research methods* (pp. 574-577). Thousand Oaks, CA: Sage Publications, Inc. doi: 10.4135/9781412963909.n295

Merriam, S. B., Caffarella, R. S., & Baumgartner, L. M. (2007). *Learning in adulthood: A comprehensive guide.* (3^{rd} ed.). Hoboken, NJ: John Wiley & Sons Inc.

Mervis, J. (2010). Obama advisers call for greater emphasis on STEM education. *ScienceInsider.* Retrieved from http://news.sciencemag.org/scienceinsider/2010/09/obama-advisers-call-for-greater.html

Michaels, S., Shouse, A. W., & Schweingruber, H. A. (2008). *Ready, set, science! Putting research to work in K-8 science classrooms.* National Academy Press: Washington, DC.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.* (2nd ed.). Thousand Oaks, CA: SAGE Publishers.

Mining Gems LLC. (2008). Indicators of Inquiry™ - Science. Retrieved from http://www.nesacenter.org/uploaded/conferences/FTI/2011/handouts/Salata/Indicators_of_Inquiry_Science_2010.pdf

Monk, D. H. (1994). Subject matter preparation of secondary mathematics and science teachers and student achievement. *Economics of Education Review, 13*(2), 125-145.

Mulhall, P., Berry, A., & Loughran, J. (2003). Frameworks for representing science teachers' pedagogical content knowledge. *Asia-Pacific Forum on Science Learning and Teaching, 4*(2), 1-25.

Mundry, S., Keeley, P., & Landel, C. (2010). *A leader's guide to science curriculum topic study: Designs, tools and resources for professional learning*. Thousand Oaks, CA: Corwin.

Nakai, K., & Turley, S. (2003). Going the alternate route: Perceptions from non-credentialed teachers. *Education, 123*(4), 831-846.

National Academies Press. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. National Academies of Sciences, Washington, D.C. Retrieved from http://www.utsystem.edu/competitive/files/RAGS-fullreport.pdf

National Center for Alternative Certification. (2010). Introduction and Overview. Retrieved from http://www.teach-now.org/intro.cfm

National Center for Education Statistics. (2011). *The nation's report card: Science 2009*. (NCES 2011-451). Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

National Center for Education Statistics. (2012). *The nation's report card: Findings in brief: Reading and mathematics 2011: National assessment of educational progress at grades 4 and 8*. (NCES 2012-459). Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

National Commission on Excellence in Education. (1983). *A nation at risk*: *The imperative for educational reform*. Retrieved from http://teachertenure.procon.org/sourcefiles/a-nation-at-risk-tenure-april-1983.pdf

National Research Council (2000). Inquiry and the National Science Education Standards: A guide for teaching and learning. Washington DC: National Academy Press.

National Research Council (NRC). (2007). *Taking science to school: Learning and teaching science in grades K-8*. Washington, DC: The National Academies Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards*. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

New Jersey Department of Education. (2009a). *New Jersey core curriculum content standards in science*. Retrieved from https://www13.state.nj.us/NJCCCS/ContentAreaTableView_Science.aspx

New Jersey Department of Education. (2009b). *New Jersey core curriculum content standards in 21st century skills*. Retrieved from https://www13.state.nj.us/NJCCCS/ContentAreaTableView_21st.aspx

New Jersey Department of Education. (2012). *Achieve NJ: Teach. Lead. Grow*. Retrieved from http://www.state.nj.us/education/AchieveNJ/

Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. *International Journal of Science Education*, 21(5), 553-576.

Next Generation Science Standards. (2011). Retrieved from http://www.nextgenscience.org/

Next Generation Science Standards: New Jersey. (2011). Retrieved from http://www.nextgenscience.org/New-Jersey

NGSS Lead States. (2013). Next Generation Science Standards: For States, By States. Achieve, Inc. Retrieved from http://www.nextgenscience.org/

OECD (2011). Lessons from PISA for the United States, Strong Performers and Successful Reformers in Education. OECD Publishing. http://dx.doi.org/10.1787/9789264096660-en

Park, S., Chen, Y-C., & Jang, J. (2008, January). *Developing measures of teachers' pedagogical content knowledge for teaching high school biology.* International Conference of the Association for Science Teacher Education, St. Louis, MI. as cited in Park, S., Jang, J-Y., Chen, Y-C., & Jung, J. (2011).

Park, S., Jang, J.-Y., Chen, Y.-C., & Jung, J. (2011). Is pedagogical content knowledge (PCK) necessary for reformed science teaching? Evidence from an empirical study. *Research in Science Education*, *41*(2), 245-260. doi: 10.1007/s11165-009-9163-8

Park, S., & Oliver, S. (2008). Revisiting the conceptualisation [*sic*] of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education, 38*(3), 261-284. doi: 10.1007/s11165-007-9049-6

Patton, M. (1990). *Qualitative evaluation and research methods* (pp. 169-186). Beverly Hills, CA: Sage. Retrieved from http://legacy.oise.utoronto.ca/research/field-centres/ross/ctl1014/Patton1990.pdf

Patton, M. Q. (2002). *Qualitative research and evaluation methods.* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Piburn, M., & Sawada, D. **(**2000). *Reformed teaching observation protocol (RTOP): Reference manual.* ACEPT Technical Report No. IN00-3. Tempe, AZ: Arizona State University.

Polikoff, M. S. (2013). Teacher education, experience, and the practice of aligned instruction. *Journal of Teacher Education, 64*(3), 212-225.

Porter, A. C. (2002). Measuring the content of instruction: Uses in research and practice. *Educational Researcher*, *31*(7), 3-14.

Rapley, T. (2007). *Doing conversation, discourse and document analysis.* Los Angeles, CA: Sage Publications.

Ripley, A. (2010, January/February). What makes a great teacher? *The Atlantic*. Retrieved from http://www.teachingquality.org/sites/default/files/Great_Teacher_Atlantic_Jan-Feb2010.pdf

Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools, and academic achievement, *Econometrica*, *73*(2), 471-458.

Rochkind, J., Ott, A., Immerwahr,J., Doble, J., & Johnson, J. (2007). Lessons learned: New teachers talk about their jobs, challenges and long-range plans. *A Report from the National Comprehensive Center for Teacher Quality and Public Agenda, 1*, 1-33. Retrieved from http://www.publicagenda.org/files/lessons_learned_1.pdf

Rosen, L. H., & Underwood, M. K. (2010). Observations. In N. J. Salkind (Ed.), *Encyclopedia of research design* (pp. 953-955). Thousand Oaks, CA: Sage Publications, Inc. doi: 10.4135/9781412961288.n284

Rossman, G. B., & Rallis, S. F. (2003). Learning in the field: An introduction to qualitative research. (2nd ed.). Thousand Oaks, CA: Sage Publications.

Rubin, H. J., & Rubin, I. S. (2012). *Qualitative interviewing: The art of hearing data.* (3rd ed). Los Angeles, CA: Sage.

Sadler, T. D. (2006). Promoting discourse and argumentation in science teacher education. *Journal of Science Teacher Education*, 17(4), 323-346. doi:10.1007/s10972-006-9025-4

Saldaña, J. (2009). The coding manual for qualitative researchers. Thousand Oaks, CA: Sage Publications.

Sandelowski, M. (2008). Theoretical saturation. In Lisa M. Given (Ed.), *The SAGE encyclopedia of qualitative research methods.* (pp. 876-877). Thousand Oaks, CA: SAGE Publications, Inc. doi: http://dx/doi.org.ezproxy.rowan.edu/10.4135/9781412963909.n456

Sanders, W. L., & Rivers, J.C. (1996, November). *Cumulative and residual effects of teachers on future student academic achievement*. Knowxville:TN: University of Tennessee Value-Added Research and Assessment Center.

Saumure, K., & Given, L. (2008). Data saturation. In Lisa M. Given (Ed.), *The SAGE encyclopedia of qualitative research methods.* (pp. 196-197). Thousand Oaks, CA: SAGE Publications, Inc. doi: http://dx/doi.org.ezproxy.rowan.edu/10.4135/9781412963909.n99

Schroeder, C. M., Scott, T. P., Tolson, H., Huang, T., & Lee, Y. (2007). A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the United States. *Journal of Research in Science Teaching, 44*(10), 1436-1460.

Shannon, J. C. (2006). *How is PCK embodied in the instructional decisions teachers make while teaching chemical equilibrium?* (Order No. 3224289, University of Washington). *ProQuest Dissertations and Theses*, 434-n/a. Retrieved from http://search.proquest.com/docview/304970551 (304970551)

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), 1-22.

Spang, E. J. (2008). *How does teacher education make a difference in our schools? Beginning science teachers' and their students' understanding and use of scientific inquiry.* (Order No. 3332930, Stanford University). *ProQuest Dissertations and Theses,* 238-n/a. Retrieved from http://ezproxy.rowan.edu/login?url=http://search.proquest.com/docview/304470369?accountid=13605. (304470369).

Stake, R. E. (1978). The case study method in social inquiry. *Educational Researcher, 7*(2), 5-8. Retrieved from http://links.jstor.org/sici?sici=0013-189X%28197802%297%3A2%3C5%3ATCSMIS%3E2.0.CO%3B2-I

Stake, R. E. (1995). *The art of case study research.* Thousand Oaks, CA: Sage Publications, Inc.

Stake, R. E. (2006). *Multiple case study analysis.* New York, NY: The Guilford Press.

Stake, R. E. (2010). *Qualitative research: Studying how things work*. New York, NY: The Guilford Press.

State of New Jersey Department of Education. (2010). *Certification and induction*. Retrieved from http://www.state.nj.us/education/educators/license/alternate.pdf

Stronge, J. H. (2007). *Qualities of effective teachers*. (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Stronge, J. H. (2010). *Effective teachers = student achievement: What the research says*. Larchmont, NY: Eye of Education.

Tal, T., Krajcik, J. S., & Blumenfeld, P. (2006). Urban schools' teachers enacting project-based science. *Journal of Research in Science Teaching*, *43*(7), 722-745.

Thier, M. (2010). Developing persuasive voices in the science. *Science and Children*, *48*(3), 70-74.

Tucker, P. D., & Stronge, J. H. (2005). *Linking teacher evaluation and student learning*. Alexandria, VA: Association for Supervision and Curriculum Development.

Tyler, J. H., Taylor, E. S., Kane, T. J., & Wooten, A. L. (2010). Using student performance data to identify effective classroom practices. *American Economic Review*, *100*(2), 256-260.

U.S. Congress Joint Economic Committee. (April, 2012). STEM Education: Preparing for the jobs of the future. Washington, D.C. Retrieved from http://www.jec.senate.gov/public/index.cfm?a=Files.Serve&File_id=6aaa7e1f-9586-47be-82e7-326f47658320

U.S. Department of Education. (1999). *Highlights from TIMSS: The third international mathematics and science study*. Retrieved from http://nces.ed.gov/pubs99/1999081.pdf

U.S. Department of Education. (2007). *Report of the academic competitiveness council*, Washington, D.C. Retrieved from http://www2.ed.gov/about/inits/ed/competitiveness/acc-mathscience/report.pdf

Van Driel, J. H., De Jong, O., & Verloop, N. (2002). The development of preservice chemistry teachers' pedagogical knowledge. Sc*ience Education*, *82*, 572-590. doi: 10.1002/sce.10010

Van Driel, J. H., Verloop, N., & De Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching, 35*(6), 673–695.

Veal, W. R., & MaKinster, J. G. (1999). Pedagogical content knowledge taxonomies. *Electronic Journal of Science Education*, *3*(4), 1-16.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.). Cambridge: Harvard University Press.

Wei, R. C., Darling-Hammond, L., & Adamson, F. (2010). *Professional development in the United States: Trends and challenges*. Dallas, TX. National Staff Development Council.

Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad.* Dallas, TX. National Staff Development Council.

Weick, K. E. (1995). *Sensemaking in organizations.* Thousand Oaks, CA: Sage.

Weick, K. E. (2012). Organized sensemaking: A commentary on processes of interpretive work. *Human Relations*, *65*(1), 141-153. doi:10.1177/0018726711424235

Weick, K. E. & Quinn, R. E. (1999). Organizational change and development. *Annual Review of Psychology, 50*, 361-86.

Weick, K. E., Sutcliffe, K. M., & Osbtfeld, D. (2005). Organizing and the process of sensemaking. *Organization Science*, *16*(4), 409-421.

Wenglinsky, H. (2000). *How teaching matters: Bringing the classroom back into discussions of teacher quality*. Princeton, NJ: Educational Testing Service.

Wenglinsky, H. (2002, February). How schools matter: The link between teacher classroom practices and student academic performance. *Education Policy Analysis Archives, 10*(12). Retrieved from http://epaa.asu.edu/ojs/article/view/291/417

Wenglinsky, H. (2006, December/2007, January). The science training teachers need. *Educational Leadership, 64*(4), 24-29.

Wilson, S. M., Floden, R. E., & Ferrini-Mundy, J. (February, 2001). *Teacher preparation research: Current knowledge, gaps, and recommendations.* Seattle: Center for the Study of Teaching and Policy, University of Washington. Retrieved from http://www.stcloudstate.edu/tpi/initiative/documents/preparation/Teacher%20Preparation%20Research-Current%20Knowledge,%20Gaps,%20and%20Recommendations.pdf

Yin, R. (2009). *Case study research: Design and method.* (4th ed.). Thousand Oaks, CA: Sage Publications, Inc.

Zembal-Saul, C. (2009). Learning to teach elementary school science as argument. *Science Education*, *93*(4), 687-719. doi:10.1002/sce.20325

Appendix A

Site Consent Form

Kim Feltre
603 Lindner
Court
Raritan, NJ
08869
February 2015

Gatekeeper for school districts of participants
Addresses for school districts of participants

Dear :

I am currently a doctoral candidate in the Educational Leadership Doctoral program at Rowan University working to complete my dissertation. I will be conducting a qualitative case study to investigate how alternate route science teachers' learning experiences inform a change in their classroom practice and facilitate the development of their pedagogical content knowledge (PCK). Through engaging in a qualitative case study, this research will inform what learning experiences alternate route science teachers found to be most useful in promoting their pedagogical content knowledge development, as evidenced by how alternate route science teachers build upon their science background and translate their alternate route program learning experiences into practice to promote student learning. Direct interpretation of the data will be conducted to draw key meaning from the data, to search for patterns, and to develop assertions regarding which learning experiences are perceived by alternate route science teachers to promote their pedagogical content knowledge development.

To complete this research project, I need to conduct interviews with, observations of, and collect documents from science teachers who have participated in an alternate route program. Interviews will last forty-five to sixty minutes. If a follow up interview is needed, it will last no more than thirty minutes. All interviews and observations will be scheduled at the participant's convenience. During the interviews, I will be taking notes and recording the interview in order to transcribe the interview, as well as re-listen to the interview. During the observations, I will be taking notes. In addition to conducting interviews and observations, I will also be collecting syllabi for courses, lesson plans, teacher worksheets, teacher notes/class agenda, student work, professional development certificates, and professional development handouts.

I will assure the participants that all of the data that is collected will be kept confidential, will be coded for confidentiality, and will not be used in any evaluative manner. I will summarize and share my findings with the participants to verify that the findings are a true reflection of their experiences. They will also be told that at any time they may withdraw from the study. Additionally, participants will not be identified with your alternate route program and your University/school district will not be identified or associated with the data.

I am requesting permission to pursue this research with alternate route science teacher voluntary participants within your facility. If you have any questions or concerns regarding this research, please do not hesitate to ask. Thank you in advance for your time, consideration, and support.

Sincerely,

Kim Feltre

I understand that the contact person for any questions regarding this research is Kim Feltre, 603 Lindner Court, Raritan, New Jersey, 08869. I understand that for any issues or questions regarding this research that were not satisfactorily addressed I may contact Dr. Issam Abi-El-Mona, Dissertation Chair, Rowan University, Glassboro, New Jersey, 08028. Email address: abi-el-mona@rowan.edu.

By providing a signature below, I agree to permit and support Kim Feltre's access to this site so that she can collect data from alternate route science teachers who have agreed to participate in the above described research exploring alternate route science teacher development of pedagogical content knowledge.

Name(print):____________________________

Signature: ______________________________ Date:__________________

Appendix B

Participant Informed Consent Letter

February 2015

Dear ,

I am currently a doctoral candidate in the Educational Leadership Doctoral program at Rowan University working to complete my dissertation. I will be conducting a qualitative case study to investigate how alternate route science teachers' learning experiences inform a change in their classroom practice and facilitate the development of their pedagogical content knowledge (PCK). Through engaging in a qualitative case study, this research will inform what learning experiences alternate route science teachers found to be most useful in promoting their pedagogical content knowledge development, as evidenced by how alternate route science teachers build upon their science background and translate their alternate route program learning experiences into practice to promote student learning. Data will be analyzed to search for patterns and to develop assertions regarding which learning experiences are perceived by alternate route science teachers to promote their pedagogical content knowledge development.

To complete this research project, I need to conduct interviews with, observations of, and collect documents from science teachers who have participated in an alternate route program. The interview will last forty-five to sixty minutes. If a follow up interview is needed, it will last no more than thirty minutes. All interviews and observations will be scheduled at your convenience. During the interviews, I will be taking notes and recording the interview in order to transcribe the interview, as well as re-listen to the interview. During the observations, I will be taking notes. In addition to conducting interviews and observations, I will also be collecting syllabi for courses, lesson plans, teacher worksheets, teacher notes/class agenda, student work, professional development certificates, and professional development handouts. Data collection will begin February 2015 and end April 2015.

All of the data that is collected will be kept confidential, will be coded for confidentiality, and will not be used in any evaluative manner. I will summarize and share my findings with you to verify that the findings are a true reflection of your experiences.

While I hope that you will want to participate, you are under no obligation to participate in this research. If you choose to participate, you may withdraw from the research at any time. If you are interested in participating in this qualitative research case study, please fill out your name on the next page and return to me at your earliest convenience. Thank you in advance for your consideration.

Sincerely,

Kim Feltre

Kim Feltre

I understand that the contact person for any questions regarding this research is Kim Feltre, 603 Lindner Court, Raritan, New Jersey, 08869. I understand that for any issues or questions regarding this research that were not satisfactorily addressed I may contact Dr. Issam Abi-El-Mona, Dissertation Chair, Rowan University, Glassboro, New Jersey, 08028. Email address: abi-el-mona@rowan.edu.

By providing the contact information below, I agree to participate in the above described research exploring alternate route science teacher development of pedagogical content knowledge.

Name (print): ___________________________

Signature:________________________________

Contact information:

Email: __________________________________ Phone: ________________________________

Date: ______________________

Appendix C

Semi-Structured Interview Protocol - Teachers

Thank you for agreeing to participate in this interview. You signed the informed consent form, but I want to remind you that your participation is voluntary and that you can withdraw from this study at any time. This interview should last no more than 45-60 minutes. Interview questions will be asked aloud, this interview will be digitally audio-taped, and I will be taking notes during the interview. You will have an opportunity to review the transcribed interview and make any changes. All transcriptions will be kept confidential, will be coded for confidentiality, and will not be used in any evaluative manner. Do you have any questions?

Interviewee name: ______________________________________

1. What did you learn about in your alternate route classes?

   Follow-up: Which of these experiences do you feel helped you in the science classroom and why?

   Follow-up: What professional development opportunities were offered in your district in which you engaged?

   Follow-up: Which of these experiences do you feel helped you in the science classroom and why?

2. In what way do you feel that what you learned in your alternate route courses is being used in practice?

   Follow-up: How did you modify your instructional strategies as a result of your learning from your alternate route courses?

   Follow-up: Can you provide an example?

   Follow-up: Do you have any artifacts (handouts, class activities, etc.) that you feel demonstrate your application of your learning from alternate route courses to classroom practice?

   Follow-up: What does this artifact show?

3. What is the role of pedagogical content knowledge in teaching?

   Follow-up: What does teaching science look like to you?

Follow-up: How do you think students learn science?

Follow-up: How would you define inquiry?

Follow-up: What is the role of inquiry in science teaching and learning?

4. How have your alternate route learning experiences informed your pedagogical content knowledge?

Appendix D

Teacher-Generated Artifacts Summary Form

Site:
Teacher-Generated Artifact:
Date:

Name or description of teacher-generated artifact:

Significance or importance of teacher-generated artifact:

Brief summary of contents:

Appendix E

Pre- and Post-Observation Interview Questions

Pre-Observation

1. Could you briefly describe what concepts in the lesson I will observe are the most important for your students to understand and why?
2. What kinds of things did you take into consideration in planning this lesson? (students' prior knowledge of the topic, learning difficulties with specific science concepts, etc.)
3. What misconceptions do your students have about this topic? How do you know?
4. What strategies did you use to understand students' understanding of this topic?
5. What evidence are you looking for that students have been successful in addressing the goals for the lessons?

Post-Observation

1. What do you consider the most effective teaching moment was in the lesson?
2. What signaled you that students were learning?
3. Were there any student misconceptions you identified during the class of which you weren't aware? If yes, how did you address these misconceptions?
4. Did you make any changes in the class that I just observed that differed from the other class periods or lesson plan? Why?
5. How do you see your alternate route learning experiences impacting your classroom practice and subsequently student learning?

Appendix F

Classroom Observation Protocol

The Indicators of Inquiry™ observation protocol was developed by in accordance with the five essential features of inquiry as described by the National Research Council (2000) to look for "qualities that would be observed in the best of all science classrooms" (Mining Gems LLC, 2008, p.1). This observation protocol encourages free use for educational, non-profit purposes. Looking for indicators of inquiry will focus the observation on documenting teacher translation of leaning experiences into practice.

<u>Background and Use of the Indicators of Inquiry</u>

There is great interest in inquiry-based learning (IBL) because, in general, it aligns well with meaningful learning as opposed to rote learning. There is interest to empower students to develop inquiry skills, be reflective about their own learning, and become critical and creative thinkers. Do all of these interests fall into IBL strategies? Is IBL defined best in broad or narrow terms?

To some IBL means all pedagogy that include questioning as a central task and to others it is a well-defined step-by-step process, not unlike a scientific method. Some believe that any hands-on activity is, by definition, inquiry-based and others define inquiry-based learning as those that are only student-centered.

Even more challenging is the task of implementing IBL in the classroom, while so many understandings of what is IBL exist. The Indicators of Inquiry™ was designed to promote a balance and allow for flexibility in the application of IBL in the classroom, while maintaining qualities that would be observed in the best of all science classrooms.

Since no fixed length of a lesson can be applied to all lessons in a natural classroom setting, there are three parts to the Indicators of Inquiry™: beginning; middle; and end. Within each part is a section of possible items that may be observed during an inquiry-based lesson, a checklist created from the five essential features of inquiry*, and space for comments.

Prior to an observation by another educator, the teacher would identify which of the three parts - beginning, middle, or end - best fits the time allotted for the observation. The observer would then fill out only that sheet. The ovals would be filled in with the appropriate number, a check would be made to determine the axis of control (teacher/student), and comments would be completed. After the observation, the teacher would fill in another copy of the same sheet and a time to discuss the outcome would be set aside.

The Indicators of Inquiry™ was developed for two purposes: 1) to create a common dialogue for what defines inquiry and 2) to promote teacher self-reflection in regards to inquiry-based teaching. It was not developed to create a one-size fits all IBL design, however. It is not expected that all ovals would be rated as a 4 for a perfect inquiry-based lesson. It is not recommended that the numbers from such observations be tabulated and used to compare teachers.

Initial uses of the Indicators of Inquiry™ in Singapore have resulted in useful dialogue and greater self-reflection on IBL. If you choose to use this observation tool, then Mining Gems would encourage you to contact us and share your results. By doing so, we will compile all data sets anonymously and post a report on our website.

*National Research Council (2000). *Inquiry and the National Science Education Standards: A guide for teaching and learning*. Washington DC: National Academy Press, p 29.

TEACHER OBSERVATION CHECKLIST - INDICATORS OF INQUIRY™

BEGINNING

Teacher______________________ Observer________________________
Date_________________________ Class___________________________

Fill in each oval with a number: 1 = not at all; 2 = fair; 3 = good; 4 = best

Teacher

A. Engages students in order to reveal their current/prior understanding.

B. Gives opportunities to allow students to share their understanding.

C. Encourages students to share their understanding with each other.

D. Encourages students to share questions about the topic.

E. Listens to students' ideas and provides a positive response - one that respects the students' ideas even if they are not correct, but expresses that the discussion itself is important.

F. Engages students in a scientifically oriented question.

G. Connects the students' understanding/questions with the scientifically oriented question.

Check the best one that applies to the scientifically oriented question:

___ Learners posed the question
___ Learners selected among questions, posed new questions
___ Learners sharpened or clarified questions provided by teacher, materials, or other source
___ Learners engaged in questions provided by teacher, materials, or other source
___ No scientifically oriented question posed

Comments: ____
____
____

Indicators of Inquiry™ - Science! ©2008 Mining Gems LLC, Free use for educational, non-profit purposes - must not be altered www.mininggems.org

TEACHER OBSERVATION CHECKLIST - INDICATORS OF INQUIRY™

MIDDLE

Teacher______________________ Observer________________________
Date_________________________ Class___________________________

Fill in each oval with a number: 1 = not at all; 2 = fair; 3 = good; 4 = best

Teacher

A. Provides students with the opportunity to test their ideas.
B. Asks students questions that help lead students, without giving answers, toward a better idea of the phenomenon tested.
C. Asks students questions that help reveal their evolving understanding.
D. Demands evidence from students to support their explanations.
E. Allows students to share their ideas about the explanations with others.

Check the best one that applies to this observation:
___ Learners determined what constituted as evidence and collected it
___ Learners directed to collect certain data
___ Learners given data and asked to analyze
___ Learners given data and told how to analyze
___ Data neither collected nor given
Check the best one that applies to this observation:
___ Learners formulated explanations after summarizing evidence
___ Learners guided in process of formulating explanations from evidence
___ Learners given possible ways to use evidence to formulate explanations
___ Learners provided with evidence
___ Evidence not used
Check the best one that applies to this observation:
___ Learners independently examined other resources and formed links to explanations
___ Learners directed toward areas and sources of scientific knowledge
___ Learners given possible connections
___ Learners given all connections
___ Explanations not connected to scientific knowledge

Comments: ____
____
____

TEACHER OBSERVATION CHECKLIST - INDICATORS OF INQUIRY™

END

Teacher_______________________ Observer_________________________
Date__________________________ Class____________________________

Fill in each oval with a number: 1 = not at all; 2 = fair; 3 = good; 4 = best

Teacher

A. Encourages students to connect ideas from prior experience to the recent classroom exploration
B. Provides students the opportunity to explain another problem based on the recent classroom exploration
C. Helps clarify the students' use of scientific terminology
D. Provides students a chance to express their new ideas with each other
E. Provides time for the students to reflect on what they have learned

Check the best one that applies to this observation:
___ Learners formed reasonable and logical arguments to communicate explanations
___ Learners coached in development of communication
___ Learners provided broad guidelines to sharpen communication
___ Learners given steps and procedures for communication
___ Learners not given the chance to communicate explanations

Comments: ____
____
____
____
____
____
____
____
____
____
____
____
____
____
____

Appendix G

PCK Rubric

Instruction Stages	Elements	Level of Performance			
		Limited (1)	Basic (2)	Proficient (3)	Exemplary (4)
Planning	Understanding of Prior Knowledge including misconceptions (P-UPK)	No understanding of student common prior knowledge including misconceptions	Narrow understanding of student common prior knowledge including misconceptions	Adequate understanding of student common prior knowledge including misconceptions	Sophisticated understanding of student common prior knowledge including misconceptions
	Instructional Strategies to accommodate Prior Knowledge (P-ISPK)	No integration of the understanding of student common prior knowledge including misconceptions into instructional strategies and representations	Integration of the understanding of student common prior knowledge including misconceptions into instructional strategies and representations in a restricted way	Integration of the understanding of student common prior knowledge including misconceptions into instructional strategies and representations in an appropriate way	Integration of the understanding of student common prior knowledge including misconceptions into instructional strategies and representations in an effective way
	Understanding of Learning Difficulties (P-LD)	No understanding of student common learning difficulties	Narrow understanding of student common learning difficulties	Adequate understanding of student common learning difficulties	Sophisticated understanding of student common learning difficulties
	Instructional Strategies to accommodate Learning Difficulties (P-ISLD)	No integration of the understanding of student common learning difficulties into instructional strategies and representations	Integration of the understanding of student common learning difficulties into instructional strategies and representations in a restricted way	Integration of the understanding of student common learning difficulties into instructional strategies and representations in an appropriate way	Integration of the understanding of student common learning difficulties into instructional strategies and representations in an effective way
Implementation	Questioning to probe Student Understanding (I-QSU)	No questions to probe student understanding	Few questions to probe student understanding	Some questions to probe student understanding	Many questions to probe student understanding
	Spontaneity to challenge Misconceptions or resolve Learning Difficulties discovered (I-SMLD)	No recognition and/or no attempt to challenge student misconceptions or resolve learning difficulties discovered during instruction	Few attempts to challenge student misconceptions or resolve learning difficulties discovered during instruction	Some attempts to challenge student misconceptions or resolve learning difficulties discovered during instruction	Many attempts to challenge student misconceptions or resolve learning difficulties discovered during instruction
	Rationale for Instructional Strategies and Representations	No rationale for instructional strategies and representations	Weak rationale for instructional strategies and representations	Adequate rationale for instructional strategies and	Strong rationale for instructional strategies and representations in

	in connection with student understanding (I-RISR)	in connection with student understanding	in connection with student understanding	representations in connection with student understanding	connection with student understanding
Reflection	Focus on Student Understanding (R-SU)	No attention paid to student understanding, misconceptions, and learning difficulties	Little attention paid to student understanding, misconceptions, and learning difficulties	Some attention paid to student understanding, misconceptions, and learning difficulties	Much attention paid to student understanding, misconceptions, and learning difficulties
	Use of new understanding of student understanding to modify Instructional Strategies and representations (R-IS)	No attempt to change instructional strategies and representations based on new understanding of student understanding	Few attempts to change instructional strategies and representations based on new understanding of student understanding	Some attempts to change instructional strategies and representations based on new understanding of student understanding	Many attempts to change instructional strategies and representations based on new understanding of student understanding

Adapted from Park, S., Jang, J.-Y., Chen, Y.-C., & Jung, J. (2011). Is pedagogical content knowledge (PCK) necessary for reformed science teaching? Evidence from an empirical study. *Research in Science Education*, *41*(2), 245-260. doi: 10.1007/s11165-009-9163-8

Appendix H

Field Notes Log

Name: Kim Feltre   Observation Site:

ACTIVITY	DATE	TIME OF OBSERVA-TION	DESCRIPTIVE NOTES	ANALYTIC NOTES	FIELD NOTES COMPLETED

Appendix I

Coding

Label for initial coding	Codes	Research question addressed by code
Learning Experiences	LE	1
Professional Development	PD	1
Translation to Practice	TP	2
Instructional Strategies	IS	2
Pedagogical Content Knowledge	PCK	3
Inquiry-based Learning	IBL	1, 2, 3
Student Engagement	SEng	1, 2, 3
Student Misconceptions	SM	2, 3
Prior Understanding	PU	1, 2, 3
Student Questioning	SQ	1, 2, 3
Student Argumentation	SA	1, 2, 3
Student Explanation	SExp	1, 2, 3
Understanding Learning Difficulties	ULD	1, 2, 3
Questioning to probe Student Understanding	QSU	1, 2, 3
Orientation to Teaching Science	OTS	3
Knowledge of Instructional Strategies and Representation	KISR	2, 3
Knowledge of Students	KS	2, 3
Knowledge of Curriculum	KC	3
Knowledge of Assessment	KA	3

Research Questions:

1. What aspects or learning experiences offered by an alternate route program translate into first year science teachers' classroom teaching?
2. In what way(s) do alternate route science teachers' learning experiences translate into instructional practices?

3. What possible elements contribute to alternate route science teachers’ learning experiences that in effect, facilitate the development of their pedagogical content knowledge?

Appendix J

Pilot

Alternate route teachers were chosen for the pilot based on convenience sampling; teachers to whom this researcher had access and who agreed to participate in the pilot (Auerbach & Silverstein, 2003; Patton, 1990). Five former alternate route teachers ranging in experience from two to twenty-one years of teaching experience were interviewed and observed using the data collection instruments. While these teachers are not first year alternate route science teachers, they all could recall their alternate route program learning experiences and their lived experiences their first year of teaching.

The pilot alerted this researcher to elements of interview techniques which support the objectives of the study and those which detract from these objectives (Stake, 2010). The teachers in the pilot provided feedback on the answerability of the questions asked during the semi-structured interview. The interviews using the interview protocol ranged from twenty to forty minutes in length. The pilot teachers were able to provide detailed accounts of their alternate route learning experiences, which experiences helped them in their teaching, and whether or not they modified their instructional strategies as a result of their alternate route learning experiences. Teachers were also able to provide responses to what teaching and learning science look like and the role of inquiry in science teaching and learning. The question; "How would you define pedagogical content knowledge?" unnerved all participants and they all wanted feedback on whether or not they answered the question correctly. Since the goal of the question was to gain understanding of teacher's awareness of PCK and the role PCK plays in their teaching, this question was reworked to "What is the role of pedagogical content knowledge in teaching?" and an additional question, "How have your alternate route learning experiences informed your pedagogical content knowledge?" was added.

In addition, the teachers provided feedback on the answerability of the pre- and post-observation interview questions. Consensus was that there were too many questions and the questions regarding understanding of student misconceptions may be difficult to answer. Thanks to participant feedback, the questions were reworked and reduced in number. As understanding student misconceptions is a characteristic of PCK, understanding whether or not a teacher has difficulty with identifying and addressing student misconceptions is vital to this research study. The pilot informed me that this researcher should pay particular attention to participant answers to these questions.

By using the observation protocol and the PCK Evidence Reporting Table during the pilot observations, this researcher gained a deeper understanding of what to look for and record during observations. Additionally, this researcher gained an understanding of the types of data that can be gathered during observations using these instruments. By becoming familiar with the indicators of inquiry, as well as the characteristics of PCK, to look for during an observation, this researcher has become more adept at capturing data that can apprise the answers to the research questions.

The pilot served to validate that the data collection instruments produced data that can speak to the research questions of the study. Results from the pilot informed minor adjustments to interview questions and honed skills for observation to ensure data collection in alignment with the research questions being asked.

Appendix K

PCK Rubric Scores for Participants

Instruction Stages	**Elements**	**Level of Performance**			
		Limited (1)	Basic (2)	Proficient (3)	Exemplary (4)
Planning	Understanding of Prior Knowledge including misconceptions (P-UPK)	No understanding of student common prior knowledge including misconceptions	**Narrow** understanding of student common prior knowledge including misconceptions **(Dana, Henry)**	**Adequate** understanding of student common prior knowledge including misconceptions **(Nancy)**	Sophisticated understanding of student common prior knowledge including misconceptions
	Instructional Strategies to accommodate Prior Knowledge (P-ISPK)	No integration of the understanding of student common prior knowledge including misconceptions into instructional strategies and representations	Integration of the understanding of student common prior knowledge including misconceptions into instructional strategies and representations in a **restricted** way **(Dana, Henry)**	Integration of the understanding of student common prior knowledge including misconceptions into instructional strategies and representations in an **appropriate** way **(Nancy)**	Integration of the understanding of student common prior knowledge including misconceptions into instructional strategies and representations in an effective way
	Understanding of Learning Difficulties (P-LD)	**No** understanding of student common learning difficulties **(Dana)**	**Narrow** understanding of student common learning difficulties **(Henry, Nancy)**	Adequate understanding of student common learning difficulties	Sophisticated understanding of student common learning difficulties
	Instructional Strategies to accommodate Learning Difficulties (P-ISLD)	**No** integration of the understanding of student common learning difficulties into instructional strategies and representations **(Dana, Nancy)**	Integration of the understanding of student common learning difficulties into instructional strategies and representations in a **restricted** way **(Henry)**	Integration of the understanding of student common learning difficulties into instructional strategies and representations in an appropriate way	Integration of the understanding of student common learning difficulties into instructional strategies and representations in an effective way
Implementation	Questioning to probe Student	No questions to probe student understanding	**Few** questions to probe student	**Some** questions to probe student	Many questions to probe student

	Understanding (I-QSU)		understanding **(Dana)**	understanding **(Henry, Nancy)**	understanding
	Spontaneity to challenge Misconceptions or resolve Learning Difficulties discovered (I-SMLD)	No recognition and/or no attempt to challenge student misconceptions or resolve learning difficulties discovered during instruction	**Few** attempts to challenge student misconceptions or resolve learning difficulties discovered during instruction **(Dana)**	**Some** attempts to challenge student misconceptions or resolve learning difficulties discovered during instruction **(Henry, Nancy)**	Many attempts to challenge student misconceptions or resolve learning difficulties discovered during instruction
	Rationale for Instructional Strategies and Representations in connection with student understanding (I-RISR)	**No** rationale for instructional strategies and representations in connection with student understanding **(Dana)**	**Weak** rationale for instructional strategies and representations in connection with student understanding **(Henry, Nancy)**	Adequate rationale for instructional strategies and representations in connection with student understanding	Strong rationale for instructional strategies and representations in connection with student understanding
Reflection	Focus on Student Understanding (R-SU)	No attention paid to student understanding, misconceptions, and learning difficulties	**Little** attention paid to student understanding, misconceptions, and learning difficulties **(Nancy)**	**Some** attention paid to student understanding, misconceptions, and learning difficulties **(Dana, Henry)**	Much attention paid to student understanding, misconceptions, and learning difficulties
	Use of new understanding of student understanding to modify Instructional Strategies and representations (R-IS)	No attempt to change instructional strategies and representations based on new understanding of student understanding	**Few** attempts to change instructional strategies and representations based on new understanding of student understanding **(Nancy)**	**Some** attempts to change instructional strategies and representations based on new understanding of student understanding **(Dana, Henry)**	Many attempts to change instructional strategies and representations based on new understanding of student understanding

Participant	**Dana**	**Henry**	**Nancy**
Participant Raw Score	**17/36**	**22/36**	**21/36**
Participant percentages	**47%**	**61%**	**58%**
Level of Performance	**1.9**	**2.4**	**2.3**

Note. Participant ratings are indicated by boldface names on the rubric. Adapted from Park, S., Jang, J.-Y., Chen, Y.-C., & Jung, J. (2011). Is pedagogical content knowledge (PCK) necessary for reformed science teaching? Evidence from an empirical study. *Research in Science Education, 41*(2), 245-260. doi: 10.1007/s11165-009-9163-8