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An Analysis of the Perceived Impact of Lesson Study on Improving Secondary School STEM Teacher Effectiveness

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AN ANALYSIS OF THE PERCEIVED IMPACT OF LESSON STUDY ON IMPROVING SECONDARY SCHOOL STEM TEACHER EFFECTIVENESS

by

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ABSTRACT

The purpose of this study was to determine the extent to which participating in lesson study was perceived to have an impact on teacher effectiveness. Secondary STEM graduates who come into education need a model of collaborative reflective practice for continuous improvement. Lesson study is one possible model of professional learning that is both reflective and collaborative (Sims & Walsh, 2009, p. 731). The cyclical nature of lesson study makes it a natural fit for continuous improvement. Yet, little research into the effectiveness of lesson study as a tool for new teacher preparation or for middle and high school teachers exists.

As part of the University of Central Florida's RTP^3 program, resident teachers from three school districts participated in lesson study. Their reflections on participating in lesson study were analyzed and interviews with designees from each school district were conducted. The resident teachers' reflections and the interviews with partner school district designees were analyzed using the constant comparison method (Parry, 2004). The reflections were closely examined for trends and patterns, and as commonalities emerged, they led to the findings of this study. After review of the school district lesson study models, they were confirmed and explored during the interviews with school district designees.

Analysis showed lesson study was perceived to be beneficial by the resident teachers and two of the three school district designees described positive effects gained from participating in lesson study through RTP^3. The literature review and the results of this study demonstrate that lesson study is a valuable tool for professional learning in both novice and veteran teachers. Themes frequently observed in lesson study reflections included increased focus on students, the value found in collaboration, and a desire to participate on future lesson study teams. Teachers,

teacher preparation programs, and school administrators should consider the benefits of participating in lesson study and attempt to develop a plan to include this method of professional learning in their school or teacher preparation program.

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CHAPTER 1
THE PROBLEM AND ITS CLARIFYING COMPONENTS

Background of the Study

As Florida's Department of Education (FLDOE) continued to work to achieve its stated vision of having "an efficient world-class education system that engages and prepares all students to be globally competitive for college and careers," focus began to increase on teacher preparation programs (Florida State Board of Education, 2012, p. 6). A United States Department of Education report indicated that as many as 62% of new teachers felt unprepared for the realities of the classroom (United States Department of Education, 2011, p. 5). In his 2011 State of the Union address, President Barack Obama called for "a new effort to prepare, over the next decade, 100,000 science, technology, engineering and math (STEM) teachers with strong teaching skills and deep content knowledge" (Office of Science and Technology Policy, 2013, p. 2). Highly qualified STEM teachers are needed as recent assessments indicate that students from the United States are "failing to compete with other countries when it comes to student performance and interest in STEM subject areas" (Daugherty, 2013, p. 1). In an effort to better prepare teachers and to meet the growing need for highly qualified STEM teachers, the University of Central Florida partnered with five local school districts to develop the Resident Teacher Professional Preparation Program (RTP^3).

As this study is specific to the graduate students participating in RTP^3, some background on the program is necessary. The purpose of the Resident Teacher Professional Preparation Program (RTP^3) was "to prepare high performing content experts to teach mathematics and science in Florida's middle and high schools" (Resident Teacher Professional

Preparation Program, 2012, p. 58). According to the University of Central Florida College of Education and Human Performance (UCF CEDHP) RTP^3 website, the goals of the program included:

1. raising mathematics and science achievement and career/college readiness of all 6-12 students by increasing the effectiveness of teacher preparation programs to better prepare teacher candidates through job-embedded preparation and induction;
2. improving and innovating teacher preparation content, delivery, and performance measures in order to increase the number of effective mathematics and science teachers who are eligible for employment;
3. recruiting, preparing, and supporting teacher candidates in mathematics and science to be effective during and after induction;
4. identifying and developing effective mentor teachers to support RTP^3 resident teacher success; and
5. designing the RTP^3 teacher preparation program to include a) integrated courses/mini modules, b) ongoing lesson study as reflective practice/professional learning, and c) use of existing and emerging technological solutions such as game/simulations for teaching and learning and incorporating TeachLIVE^{TM}.

These objectives support the two broad goals included in the initial RTP^3 proposal, "to raise mathematics and science achievement and career/college readiness of all 6-12 students by increasing the effectiveness of teacher preparation programs to better prepare teacher candidates through job-embedded preparation and induction," and "to improve and innovate teacher preparation content, delivery, and performance measures in order to increase the number of

effective mathematics and science teachers who are eligible for employment" (Swan, Godek, Zhou, Coulombe-Quach, & Katzenmeyer, 2012, p. 2). At the time this study began, in January 2014, the first cohort of resident teachers in RTP^3 had completed the program and Cohort Two was in the middle of their job embedded two-semester internship. Lesson study was a component of RTP^3 objective 5, introduced during the first semester of coursework and implemented during the two-semester internship with one or two cycles.

With new teachers believing themselves unprepared for the classroom and a national need for more highly qualified STEM teachers, results of this study, demonstrating the extent to which lesson study was a valuable tool for teacher growth, would indicate that other students enrolled in new teacher preparation programs may or may not benefit from participating in lesson study. No matter the outcome, school leaders will benefit as they will be able to make more informed decisions about this aspect of lesson study. As professional learning should be held within the context of the teacher's practice and be "relevant to the teaching and learning needs of both teachers and students," lesson study may prove to be an option for empowering teacher improvement (Yuen, 2012, p. 388).

Statement of the Problem

The problem to be studied was that secondary STEM graduates who come into education need a model of collaborative reflective practice for continuous improvement. Lesson study is one possible model of professional learning that is both reflective and collaborative (Sims & Walsh, 2009, p. 731). The cyclical nature of lesson study makes it a natural fit for continuous improvement. Little research into the effectiveness of lesson study as a tool for new teacher preparation or for middle and high school teachers exists. Therefore, an examination of lesson

study as the model of collaborative, reflective practice for continuous improvement was appropriate and necessary.

Purpose of the Study

The purpose of the study was to determine the extent to which participation in a lesson study research team was perceived to have an impact on teacher effectiveness. While lesson study is well regarded, little research linking the practice to increased student achievement exists. Collecting and analyzing these data will shine a light on the perceived benefits identified by new teachers as related to use of lesson study. The data collected for this study will demonstrate whether or not new teacher preparation programs should consider lesson study as a tool for teacher learning.

Significance of the Study

This study could be significant should the findings demonstrate that the RTP^3 resident teachers perceived that lesson study played a meaningful part in their development as reflective practitioners and teachers. Little research has been conducted examining the use of lesson study within teacher preparation programs. Furthermore, one of the five RTP^3 partner school districts is a virtual school district, making this research meaningful for those seeking to prepare teachers who may be instructing online. This research will provide new insight into effective methods of preparing new teachers and will hold a great deal of practical application for both school district leaders and teacher preparation programs.

Definition of Terms

The following definitions are provided to clarify terminology used in this research study.

Lesson Study – the process in which a group of teachers collaborate to better their practice. Typically involves four steps—examining the curriculum and developing goals, creating the lesson, teaching the lesson, and reflecting upon what went well and what could be improved upon (Lewis & Hurd, 2011).

Perceived Value – how worthwhile the RTP³ participants believed lesson study to be. Did they think it improved their teaching? Or did they believe it was an utter waste of their time?

RTP^3 – the Resident Teacher Professional Preparation Program, a Race to the Top-funded University of Central Florida graduate degree program designed to attract highly qualified STEM teachers to five school districts in Central Florida (University of Central Florida College of Education and Human Performance, 2012).

Resident Teacher – a student enrolled in the Resident Teacher Professional Preparation Program at the University of Central Florida and a full time teacher. Each student is working toward the completion of a Master of Arts in Teaching degree.

School District A – A large, urban school district in Central Florida serving about 180,000 students.

School District B – A medium-sized, suburban school district in Central Florida serving about 65,000 students.

School District C – A medium-sized, rural school district in Central Florida serving about 40,000 students.

School District D – A medium-sized, suburban school district in Central Florida serving about 60,000 students.

School District E – An internet-based public school district serving over 140,000 students in half-credit enrollments.

Theoretical Framework

The research of Hattie (2008) has shown quality of teaching has a large impact on student learning with an effect size of 0.77 (p. 244). Improving teacher effectiveness should, therefore, be a primary goal of every school leader who wishes to improve student achievement. Professional learning is one of the most common and practical methods of improving teacher effectiveness. In *Teacher Learning: What Matters?* Linda Darling-Hammond and Nikole Richardson (2009) identify three traits necessary for professional learning to lead to improvement in instruction and student achievement. The authors begin by identifying the importance of professional learning being centered on student learning. They address that it should be part of the year's school improvement plan rather than anything done in isolation. The final suggestion they make is that teacher learning should be active and sustained, pointing out that "professional development lasting 14 or fewer hours showed no effects on learning. The largest effects were for programs offering 30-100 hours spread out over 6-12 months" (Darling-Hammond & Richardson, 2009, p. 49). These are all qualities found in Lesson Study, a research-supported type of professional learning. As a cycle of lesson study typically takes 6-8 hours, the completion of multiple cycles over the course of a school year is necessary to reach the desired 30-100 hours spread out over 6-12 months.

Lesson Study began in Japan and has "spread rapidly in North America since the first published description in 1997" (Lewis & Hurd, 2011, p. 1). In practice, Lesson Study involves four steps: studying curriculum and formulating goals, planning the lesson, conducting the research lesson, and reflecting upon the research lesson. These steps are not done alone, but rather completed together with a team of teachers from the same curricular area (Lewis & Hurd, 2011, p. 2). According to many studies, lesson study has numerous benefits. In *Lesson Study: Beyond Coaching*, Lewis, Perry, Foster, Hurd, and Fisher (2011) found that teachers working in lesson study groups to examine their instructional practices were able to "produce broad, sustainable improvement" (p. 64). Lesson study helped improve instruction for both novice and veteran teachers. "All participants, whatever their level of expertise, join in the shared effort to design an effective lesson and to collect and analyze data on students' learning during the lesson" (Lewis et al., 2011, p. 66). At the conclusion of their study they added:

> Lesson study has the power to move the education profession beyond traditional hierarchical ideas of coaching and leadership toward a model that both expects and supports lifelong learning by all participants, from novice teachers to experienced leaders of professional learning. (p. 68)

Other studies have found that by reflecting on a lesson and re-teaching it, the changes made indicated teachers were more focused on students' thinking, difficulties, and abilities. Additionally, improvements in the depth of discussion and reflective questioning were noted in both quantitative and qualitative changes (Robinson & Leikin, 2011, p. 158).

Lesson study has also been growing in popularity in teacher training programs. In *Lesson Study with preservice teachers: Lessons from lessons,* Sims and Walsh (2009) examined "a 2-

year process of integrating Lesson Study into an introductory course on the principles of teaching for students majoring in early childhood education" (p. 724). In their study, Sims and Walsh used lesson study in their early childhood education class with thirty-two students. The researchers hoped their students would be encouraged through this to consider more frequently the needs and experiences of the students rather than focusing solely on what they experience as teachers. They set three broad goals for the first year of the study:

> Teaching preservice teachers to (a) analyze lessons in light of lesson goals, (b) engage in detailed discussions about instructional strategies (such as questioning techniques, anticipating student responses, and how the lesson flow affects student understanding), and (c) critique the lesson plan, not the teacher—we wanted them to move beyond superficial critiques like, "I thought the lesson went really well!" and become more comfortable with constructive criticism. (Sims & Walsh, 2009, p. 726)

At the end of the two year study, the researchers had not only met their goals but had seen a profound impact on the preservice teachers. The authors concluded that the preservice teachers who experienced lesson study would "…look at the complexities of teaching with a more investigative lens—a stance that may help them seek out and grow from the support of fellow teachers as they begin their careers" (Sims & Walsh, 2009, p. 732).

While research has demonstrated lesson study as an effective form of professional learning, it is still used relatively rarely in the United States. Lewis, Perry, Friedkin and Roth (2012) suggest in order to expand the practice in the United States, notes should be made on how well it is done in Japan where it originated. There, lesson study is "strongly linked to national and local policy through a system of small grants to schools to study a teaching innovation and

share their work through public research lessons" (p. 374). The authors gave the example of Japan developing lessons on solar energy. Two years before it was to be incorporated in their new science curriculum, hundreds of schools applied for grants to develop the materials and lessons that would be used. The teachers who won the grants tested their approach through lesson study, and in this way, the best lessons made it into the national curriculum (Lewis et al., 2012, p. 374).

Research Questions

Research questions one and two were selected to draw out the differences among school districts in how lesson study was implemented. Research question three was selected to examine the perceived value of participation in lesson study, as this information would address the problem statement as outlined above.

Research Question One

What is the lesson study model of each of the three sampled RTP^3 partner school districts?

Research Question Two

To what extent did the sampled RTP^3 partner school districts modify lesson study implementation as a result of participating in RTP^3?

Research Question Three

To what extent do the sampled RTP^3 resident teachers perceive that lesson study assisted them in improving teacher effectiveness?

Methodology

Research Design

The research design for this study used qualitative data collected through interviews and a post hoc analysis of artifacts, including resident teacher reflections of lesson study. Interviews were conducted with designees from each of the three school districts from which the sample was drawn regarding research question 1 (What is the lesson study model of each of the three sampled RTP^3 partner school districts?) and research question 2 (To what extent did partner school districts modify lesson study implementation as a result of participation in RTP^3?) These interview questions can be found in Appendix A. The sample was drawn from Cohorts 1 and 2 and all available resident teacher reflections from School Districts A, B, and E were analyzed. Only three of the five school districts were used for sampling as the other two school districts represented only 13 resident teachers in both cohorts. The artifacts analyzed include notes from advisory board meetings and reflections from the resident teachers. Reflections were completed as part of the RTP^3 job embedded two semester internship.

Participants

The population of this study included all of the 103 resident teachers from each of the five RTP^3 partner school districts.

Table 1

RTP[3] Partner School Districts

School District Name	Description	Approximate Enrollment
School District A	Urban	180,000
School District B	Suburban	65,000
School District C	Rural	40,000
School District D	Suburban	60,000
School District E	Online	140,000

However, the sample was limited to the 37 resident teachers in Cohorts One and Two of the RTP³ from School District A, School District B, and School District E (due to larger numbers of participants). Resident teachers were identified by the content area they taught (mathematics or science) and their gender.

Instrumentation

The specific questions used when interviewing the school district partners can be found in Appendix A. The interview questions were designed by the author of this study with the assistance of Dr. Rosemarye Taylor, the principal investigator of RTP[3] (and the chair of this dissertation). The questions were designed to draw out the differences between the three school districts that comprised the sample for this study.

Procedures

Approval for this research was obtained from the principal investigator for RTP³. Approval for conducting this research was also obtained from UCF's Institutional Review Board (IRB).

Resident teachers submitted lesson study reflections to their job-embedded two semester UCF intern coordinator and uploaded the reflection as a required teacher work sample that included a lesson design, student data analysis, and reflection related to the effectiveness of the lesson and what was learned from the lesson study experience. The researcher analyzed the reflection of the lesson study component only and not the lesson design itself. The UCF intern coordinators forwarded all lesson study reflections to the RTP^3 principal investigator who provided them to the researcher once approval had been obtained from the UCF IRB. The resident teachers' reflections were assigned an alphanumeric code. The resident teachers' names or schools were not identified or tied to their reflections; the reflections were identified only by the gender and subject area taught of each resident teacher.

Data Analysis

The artifacts, resident teachers' reflections, and interviews were analyzed using the constant comparison method. Constant comparison involves conducting an initial review of data to generate categories (or variables) that represent patterns in the data. The data are then analyzed repeatedly to determine if relationships between the categories exist (Parry, 2004). In this study, the reflections were closely examined for trends and patterns, and as commonalities emerged, they led to the findings of this study. After review of the school district lesson study models, they were confirmed and explored during the interviews with school district designees.

Table 2

Research Questions, Data Sources, and Analysis Methods

Number	Research Question	Data Source	Analysis Method
1	What is the lesson study model of each of the three sampled RTP^3 partner school districts?	Artifacts of models	Document Analysis
		Records of projects	Document Analysis
2	To what extent did sampled RTP^3 partner school districts modify lesson study implementation as a result of participation in RTP^3?	Interviews with the three sampled partner school district designees	Interview
3	To what extent did RTP^3 resident teachers perceive that lesson study assisted them in improving teacher effectiveness?	Peer evaluation interviews and formative evaluation reports	Document Analysis
		Participant reflections	Constant Comparison

Limitations

The study has the following limitations:

1. Each of the five RTP^3 partner school districts participating in the study is located in Florida. Therefore the results of the study may not be generalizable to the rest of the United States.
2. As all of the RTP^3 resident teachers were STEM teachers in middle and high schools, the results of the study may not be generalizable to all other content areas and grade ranges.

3. The RTP^3 resident teachers were all high-quality STEM graduates prior to entering the Master of Arts in Teaching program and teaching. Therefore the results of the study may not be generalizable to preservice undergraduate teachers.
4. There is a lack of representative data as the researcher was not able to review lesson study reflections from all resident teachers. Therefore the results may have been more accurate had more resident teacher reflections been available for analysis.

Delimitations

The study has the following delimitations:

1. All participants in the study came from the first two cohorts of University of Central Florida's RTP^3.
2. All participants completed the program successfully. Any participant who was removed from the program for grades or not continuing to teach in one of the five partner school districts was not included in the data.

Assumptions

The study operated under the following assumptions:

1. The participants were honest in their responses and answered truthfully and completely.
2. The participants completely understood every question to which they responded.
3. The participants fully engaged in both lesson study and the RTP^3.

Organization of the Study

This research is divided into five chapters. Chapter 1 contains the background of the study, the statement of the problem, purpose of the study, significance of the study, definition of terms, the theoretical framework, research questions, limitations, delimitations, and assumptions of this study.

Chapter 2 contains a review of the literature, which includes the nationwide shortage of STEM teachers, recruitment of STEM teachers, new teacher preparation programs, alternative certification programs for teachers entering the profession from another career, and lesson study.

Chapter 3 outlines the methodology used for the study. It includes an overview of RTP^3, how students were selected, instrumentation, data collection, and data analysis procedures.

Chapter 4 explains the findings of the study including the results of the data analyses for the research questions. Chapter 5 contains a summary of the whole study, discussion of the findings, implications of the findings, recommendations for additional research, and conclusions.

CHAPTER 2
REVIEW OF THE LITERATURE

Introduction

The well-documented shortage of science, technology, engineering, and mathematics (STEM) teachers (Mangrubang, 2005; Moye, 2009; Harris & Farrell, 2007) led the University of Central Florida in 2011 to create the Resident Teacher Preparation Program. This program, which was supported financially using Race to the Top dollars, offered full scholarships to recent STEM graduates interested in becoming teachers. A non-traditional teacher education program, RTP³ incorporated the use of lesson study, a professional learning method. This study examined literature related to the shortage in STEM teachers and previously attempted means of recruiting STEM teachers. The review includes literature on teacher preparation programs (including non-traditional or alternative certification programs). Also reviewed was the literature focused on lesson study and its use as a means of professional learning.

A database search was completed at the University of Central Florida with the assistance of a research librarian. Multiple databases were searched including: ERIC, Science Direct, EBSCOhost, Professional Development Collection Education, Web of Science, and Wiley Online Library. Key words used to search the databases were STEM shortage, science teacher shortage, math teacher shortage, science teacher recruitment, mathematics teacher recruitment, lesson study, alternate teacher certification, new teacher professional learning, and new teacher preparation. Numerous print and online journals were included in this literature review, including (but not limited to), *Science Educator, American Educational Research Journal, Leadership and Policy in Schools, The Technology Teacher, Middle School Journal, Journal of*

Science Teacher Education, Education Next, Journal of Mathematics Teacher Education, Issues in Teacher Education, Peabody Journal of Education, Phi Delta Kappan, International Journal of Science and Mathematics Education, and *The Educational Forum.*

The literature has been separated into three segments for the purpose of this review. The first section addresses the shortage of STEM teachers, including attempts to recruit and retain STEM teachers. Examination of teacher preparation programs, including alternative certification programs for career changers comprises the second segment. Lesson study literature is the focus of the third segment. While a thorough exploration of the literature related to lesson study was conducted, it should be noted that there are multiple gaps in the literature as there is little empirical research on lesson study related to outcome data and little research on the use of lesson study at the secondary level.

The Shortage of STEM Teachers

In his 2011 State of the Union Address, President Barack Obama outlined a goal of preparing, over the next 10 years, 100,000 new science, technology, engineering and mathematics teachers (Gambino, 2013). With this plan, he addressed a widely perceived shortage of highly qualified STEM teachers in the United States. Ingersoll & Perda (2010) noted that a series of reports from national organizations, such as the John Glenn Commission and the National Academy of Sciences, directly linked this shortage of STEM teachers to a number of problems in education and society as a whole. These problems include low educational performance when compared to other countries, the achievement gap, weakening economic strength, and national security (Ingersoll & Perda, 2010, pp. 563-564).

The shortage was also addressed by Hutchison (2012), who noted the private and public sectors' concern regarding "the capacity of school-age students in the United States being scientifically and mathematically competitive with cognitive and analytical thinking skills for a globalized world" (p. 541). Hutchison also examined what contributed to the shortage of STEM teachers, citing as contributing factors a lack of systematic professional learning and challenges retaining certified STEM teachers. Moye (2009) cited specific numbers concerning the decline in production of technology education teachers, pointing out the 5.9% decline in the number of new teachers each year from 2004-2008. Were that trend to continue, there would be "approximately 242 technology teachers produced in 2009, 196 in 2012, and 173 in 2014," despite the 1,435 technology teacher vacancies projected for 2014 (Moye, 2009, p. 34).

Peterson, Woessman, Hanushek, and Lastra-Anadon (2011) outlined similar concerns regarding the STEM teacher shortage with support from a Bureau of Labor Statistics report, claiming "of the 30 occupations projected to grow the most rapidly over the next decade, nearly half are professional jobs that require at least a college degree" (p. 51). The authors also point to a study from McKinsey's Global Institute anticipating an upcoming gap of approximately 2 million employees with needed technical and analytical skills, and recommend having a sense of urgency regarding improving scores in STEM testing (Peterson et al., 2011, p. 59). Mangrubang (2005) noted that the issues emerged not only from a lack of new STEM teachers, but from teachers leaving the profession due to feeling unhappy and unsupported in their positions, claiming that little attention is being given to retaining highly qualified teachers and addressing the concerns that are driving them away from teaching (p. 42).

The shortage of STEM teachers is not only impacting the United States. Harris and Farrell (2007) surveyed schools and teachers to examine staffing concerns. The authors outlined issues regarding the struggle Australian schools face when trying to fill physics, chemistry, and other senior science vacancies, despite the ease with which they are able to find talented life science teachers. They echoed domestic challenges regarding large numbers of teachers retiring, while teachers new to the career are dissatisfied and beginning to look to other fields as possibilities (Harris & Farrell, 2007, p. 159). A problem mentioned in this study that was not noted in the domestic studies was difficulty in recruiting teachers to serve in geographically remote schools. Harris & Farrell found it particularly alarming that of the teachers who responded to their survey, nearly 50% indicated they were unsure if they would be teaching when five years had passed. While the authors acknowledged this was expected from the veteran teachers, they were startled to note that younger teachers shared the same concern:

> More surprisingly, the number of younger, early career teachers who also reported uncertainty about their future career plans was significant. Among teachers under 35 years of age and those with less than five years' teaching experience, nearly half believed they were either not going to be teaching in five years' time or were undecided. (Harris & Farrell, 2007, pp. 167-168)

Responses to the issue, then, should not only address recruitment of teachers, but retention as well.

Recruitment and Retention Efforts

The factors responsible for STEM teacher shortages are numerous and complex. Ingersoll and Perda (2010) cited the most frequent explanation as being the result of "insufficient production of new mathematics and science teachers in the face of two demographic trends: increasing student enrollments and increasing teacher retirements" (p. 564). School districts

across the country have attempted initiatives to alleviate the shortage. These initiatives typically focus on recruiting new teachers to the field, both new college graduates and career changers. Many of these programs focus on financial aspects of becoming a teacher such as forgiving student loans, offering signing bonuses, assistance for housing, and reimbursing tuition (Ingersoll & Perda, 2010, pp. 564-565).

Moin, Dorfield, and Schunn (2005) thought colleges and universities would be better prepared to find future teachers if they understood where to focus their recruitment efforts—at what point in a student's undergraduate career, for example (p. 981). To arm universities and colleges with better information, the authors considered the following areas: proportion of science, engineering, and mathematics undergraduate students who were interested in becoming teachers (including differences according to ethnicity and gender); how interest in becoming a teacher related to other career interests and objectives; how interest in becoming a teacher varied from freshman year to senior year of a student's undergraduate career; whether trends in these answers were consistent or varied according to the student's major; and whether there was a relationship between the student's final grade point average and an interest in becoming a teacher (Moin et al., 2005, pp. 984-985).

To find the answers to these questions, Moin et al. dispersed surveys to science, engineering, and mathematics undergraduate students at two major universities. In response to the first question (regarding the proportion of interest in science, engineering and mathematics students interested in becoming teachers), the researchers discovered that the overall interest level in becoming a teacher was low, and that there were no statistically significant differences based on gender or ethnicity (Moin et al., 2005, p. 988). With respect to the second question

(interest in becoming a teacher related to other career interests), the researchers determined that an interest in becoming a teacher was "significantly negatively correlated" with career goals in the private sector, research, and other areas, but it was not significantly correlated with career goals of becoming a college instructor (Moin et al, 2005, p. 989).

The answer to the question examining how interest in becoming a teacher varies from freshman year to senior year was not encouraging—undergraduate interest in becoming a teacher is consistently low, never rising above peak levels in the junior year in which students indicated "some interest" (Moin et al., 2005, p. 991). Concerning question 4 (whether trends in these answers were tied to specific majors), the researchers noted that specific majors had no significant effect (p. 992). There was, however, an interesting trend regarding grade point average (question 5) in which students with "neither extremely weak nor extremely strong undergraduates were interested in K-12 teaching" (Moin et al., 2005, p. 993). Recruiters, therefore, should focus on undergraduate students with middle-of-the-road grade point averages, regardless of their major.

Hutchison (2012) indicated that STEM teacher recruitment should be focused on undergraduate students, include a mentoring component, and "have multiple benchmarks in place to monitor academic progress, to ensure competence in reading and writing, and to follow the pathway to completion that includes passing required state certification tests" (p. 544). Mangrubang (2005) downplayed the importance of recruiting new teachers and instead pointed out concerns related to the retention of teachers in their first five years, citing Darling-Hammond (1999) and emphasizing "nearly 50% of teachers leave within 5 years of entry; attrition rates are even higher in disadvantaged schools" (p. 42). He indicates that to counter this attrition, teachers

should be provided more support via requirements to engage in rigorous professional learning training and in-service activities to further develop their abilities as educators (Mangrubang, 2005, p. 44).

Steinke and Putnam (2008) surveyed technology educators and administrators on how strongly 28 various factors influenced teachers to accept teaching positions. Utilizing a five point Likert scale to define levels of agreement, they determined that the availability of resources, the availability of professional learning, and the level of collaboration in the work environment were among the greatest factors influencing technology teachers to accept positions as teachers (Steinke & Putnam, 2008, p. 71). Yearly raises and new teacher induction programs were also noted as strong considerations.

The researchers also noted several factors that appeared to have very little influence on technology education teachers accepting or declining teaching positions. Surprisingly, the aspects with the least amount of influence are often financial incentives; increases in compensation based on quality teaching, availability of signing bonuses, and rewarding teachers financially for the successes of their programs or the school held little sway over technology educators (Steinke & Putnam, 2008, p. 85). The researchers determined that although further research would be required to address the shortage of technology education teachers, these findings equipped school districts with a greater understanding of the population of potential technology educators. This increased understanding could be used when recruiting, they believed, "in developing programs and policies that actually entice more teachers to accept teaching positions" (Steinke & Putnam, 2008, pp. 86-87).

Luft, Wong, & Semken became so disillusioned with recruitment practices that they penned a position paper specifically to "ensure that science teacher educators do not pursue recruitment initiatives that are developed quickly in response to pressing needs, but that science teacher educators consider the critical role that recruitment plays in the process of developing a science teacher" (2011, p. 460). Chief among their concerns was a perceived lack of longitudinal studies, descriptions of specific programs used for recruitment, and research based on efforts to recruit teachers (p. 464). While they did not offer a specific outline for a recruitment plan within their position paper, they did conclude that recruitment deserves the same thoughtful consideration given to new teacher preparation programs and professional learning provided for current educators (Luft, Wong, & Semken, 2011, p. 473).

To better understand teacher retention, Tai, Liu, and Fan (2007) studied the influence of various teacher characteristics such as teaching experience, salary, and age. They also considered characteristics related to the schools in which the teachers worked, such as whether the school was public or private; rural, urban, or suburban. To find this information, Tai, Liu, and Fan examined and connected data from "two large-scale educational surveys from the *National Center for Educational Statistics* (NCES), the *Schools and Staffing Survey (SASS) of 1999-2000* and the *Teacher Follow-up Survey of 2000-2001*" (Tai, Liu, & Fan, 2007, p. 28). The data in these surveys were collected by the U.S. Census bureau and arranged by school level, private/public sector, and state. The Teacher Follow-up Survey reconnected with the teachers queried in the SASS, gathering information about their current employment status and any details on why they left their teaching position (if they left). The researchers examined the data and sorted the teachers into two categories: stayers (who were still in the place of employment

documented in SASS) and non-stayers (who either moved or left the profession entirely) (Tai, Liu, & Fan, 2007, p. 28).

The researchers sampled 916 educators who completed both the SASS and the TFS, then sifted out those who retired and any non-instructional personnel (such as administrators) to arrive at 745 mathematics and science teachers. Of the 745 teachers, 304 were stayers and 441 were non-stayers. Tai, Liu, and Fan's findings report on the influence of several factors on teachers staying put: advanced degrees (in both mathematics, science, and other education-related subjects), school earnings, salary satisfaction, teacher age, teacher experience, and what they describe as urbanicity of schools—whether they are rural, suburban or urban. The results indicated that teachers with advanced mathematics and science degrees were 1.85 times more likely to leave their current school, yet teachers with other advanced education degrees were not significantly more likely to leave. The researchers noted that teachers with advanced mathematics and science degrees who leave may be getting recruited by other schools or school districts, which are no doubt pursuing teachers with advanced mathematics and science degrees in order to have only the finest teachers on their teaching staff. Teachers who were paid more were 1.46 times less likely to leave their current school, and teachers who were satisfied with their current salary were 1.37 times less likely to leave. In general, rural school districts struggled the most in retaining both new teachers (< 3 years of experience) and veteran teachers (> 3 years of experience), and urban school districts had "higher retention rates when other teacher characteristics and school characteristics [were] controlled for" (Tai, Liu, & Fan, 2007, p. 31).

Consideration of teacher compensation, particularly the model implemented in Georgia in the last ten years, was the focus of the study by Oppong, de Araujo, Lowe, Marshall, and Singletary (2009):

> In the 2006-2007 school year, Georgia colleges and universities produced almost 2,000 early childhood teachers, while only graduating 140 mathematics teachers. The shortage of mathematics teachers in the state of Georgia is better understood when one realizes that of the 9,000 mathematics teachers in the state, 14.3% are not fully certified, and the average two-year attrition of mathematics teachers is approximately 773, or 9%. (Oppong et al., 2009, p. 3)

Sonny Perdue, then-governor of Georgia, responded to this need by signing House Bill 280, an amendment to the Quality Basic Education Act that offered extra compensation to improve teacher recruitment. The bill also provided monetary incentives for elementary education teachers who earned an endorsement in science or mathematics (Oppong et al., 2009, p. 3).

The researchers praised several aspects of the bill, including its potential to "decrease the percentage of secondary mathematics teachers that are not fully certified" (Oppong et al., 2009, p. 4). However, they did note some concerns, including the potential for the bill to erode the morale of veteran teachers who found themselves making less money in their fifth year than first year teachers receiving the additional compensation. Part of this potential frustration could be avoided if the stipulation that the endorsement be achieved post-baccalaureate be removed from the bill. This would allow all teachers who earned the endorsement to be compensated properly, regardless of when it was earned. The authors were similarly troubled that there was no guarantee providing for how long the law would be in effect. This is particularly discouraging when coupled with the knowledge that when the bill was signed, funds had not been allocated to support the nearly ten million dollar annual cost (Oppong et al., 2009, p. 5).

A number of programs designed to improve recruitment and retention of STEM teachers are also relevant to the topic of teacher preparation programs, and have, therefore, been included at the end of the recruitment and retention section. In one such study, Denton & Davis (2007) outlined a program that they established to recruit STEM teachers at Texas A&M University. The researchers noticed there were problems with both traditional undergraduate teacher preparation programs and alternative certification programs. Traditional programs, they thought, often produced teachers who were weak in their content area, while alternative certification programs were so strict and lengthy that experts of scientific and mathematical content (such as engineers and scientists) were discouraged from participating in them and becoming teachers (Denton & Davis, 2007, p. 121). With these considerations in mind, the authors developed an alternative certification program from a partnership between two colleges (Medicine & Education and Human Development). The program consisted of online courses and internet-supported experiences in the field.

Luft, Fletcher, and Fortney (2005) examined the practice of early recruitment of science teachers, exploring the experiences of teachers who participated in a recruitment program prior to a teacher education program (p. 41). Luft et al. believed that by looking at the knowledge and experiences of students in this sort of program, it would be "possible to understand the disposition of students who elect to participate in these courses, and the curricular and instructional aspects that impact students who are considering the teaching profession" (2005, p. 41). If they could understand the attitudes of teachers who chose to stay in the profession, the authors believed they could design recruitment programs to specifically target students with those attitudes.

> Luft et al. then examined the UTeach program at the University of Texas:
> The UTeach program at the University of Texas is a joint effort of faculty and staff from the Colleges of Education (COE) and Natural Sciences (CNS), along with local teachers, to prepare secondary science, mathematics and computer science teachers for the state of Texas. As a program that draws upon different knowledge bases, the program coursework consists of content and pedagogical courses at the University of Texas and field experiences in surrounding school districts. (2005, p. 42)

Among the unique aspects of the UTeach program are two single-credit recruitment courses, known as Step 1 and Step 2. The courses focus on recruitment and provide the students with field experiences in which they learn to teach both elementary and middle school science lessons. The researchers interviewed the students participating in the program and outlined three important topics that developed from the interviews: juniors and seniors in the program were more interested in and committed to education as a career than freshmen and sophomores; it was difficult to discern how well any of the students would flourish in careers as educators; and the field experiences did not make or break students' opinions about education. "Students who enjoyed the teaching experiences felt it confirmed their decision to enter education, while those who had a less than satisfying experience were still committed to staying in the program" (Luft et al., 2005, p. 47). The researchers concluded that although well-designed recruiting programs alone would not solve the teacher shortage, they did "hold out the promise of a bright start in the teacher education process" (p. 48).

The Time 2000 program was developed at Queens College of the City University of New York as a response to the shortage of mathematics teachers in the U.S.. This program was "designed to support the recruitment, preparation, and retention of prospective teachers through a close-knit learning community in which participants experience an innovative and multifaceted program for their four years of undergraduate study" (Artzt & Curcio, 2008, p. 243). In this

program, students would explore multiple aspects of becoming an educator by participating as a member of various communities—the community of the school building, the community of their internship classroom, and the community of teacher education students. Engaging in these various communities would provide scaffolding as the students transitioned into their roles as teachers (Artzt & Curcio, 2008, p. 244).

The researchers acknowledged a number of challenges they faced when attempting to recruit talented candidates for the Time 2000 program. Chief among them was trying to find students who met three qualifications: a love of mathematics, a desire to become a teacher, and an interest in attending Queens College at the City University of New York. The researchers stated that the last was especially challenging as Queens College is essentially a local college. "Aside from the well documented shortage of students who excel in mathematics, of those who do, only a small percent wish to teach and attend college in their local area" (p. 246). Artzt & Curcio cite aspects of mentoring (which are built in to the program but not explicitly stated) as one of the reasons behind the success of the program. Students are informally mentored by both their peers (over the four years in which they participate in the program) and the Time 2000 professors (Artzt & Curcio, 2008, p. 250).

Texas struggled with STEM shortages, mirroring the issues faced nationwide. These shortages throughout the state spurred the creation of new programs designed to quickly recruit and certify mathematics and science teachers. One such initiative, the Math and Science Scholars Program (MASS), "streamlines the certification process, supports preservice students through tuition remission and scholarships, and provides quality mentoring and early field experiences in K–12 classrooms with well-qualified teachers" (Scott, Milam, Stuessy, Blount, &

Bentz, 2006, p. 389). Implemented through rebuilding the teacher preparation program at Texas A&M University, the MASS program was created with the following strategic goals in mind: growing the number of qualified teacher education candidates, improving the diversity of potential teachers, enriching and enhancing the classrooms in which preservice teacher field experiences occur, building robust partnerships between the university and local school districts, aligning science and mathematics coursework with national and state standards, and helping with compensation and retention of the finest local mathematics and science teachers (Scott et al., 2006, p. 394).

As the researchers noted, "One of the hallmarks of the MASS program has been the weaving together of the funding pieces necessary to make teacher certification affordable, attractive, and financially feasible" (Scott et al., 2006, p. 397). This is possible due to the support of generous organizations offering assistance for staff salaries, scholarships, and waivers of fees. This support is provided by four funding partners: Texas A&M University System's Regents' Initiative for Excellence in Education; the Sid Richardson Foundation; TxCETP University Partners; and ITS Center for Teaching and Learning and the Robert Noyce Foundation (Scott et al., 2006, p. 402). The researchers identify these financial incentives provided to preservice teacher candidates as the greatest contributors to the success of the MASS program.

Newton, Jang, Nunes and Stone (2010) identify recruiting, preparing and retaining science and mathematics teachers as "three of the most critical problems in our nation's urban schools that serve a vast majority of children from socially and economically disadvantaged backgrounds" (p. 21). Citing concerns specific to their location in California, Newton et al.

outlined the program they recommended to the California Commission on Teacher Credentialing. The program, Cal Teach, is a teacher preparation program centered on current ideas ebbing through education, including: recruitment with consideration of diversity; integrated subject area knowledge, teaching practices, and student teaching experiences; and professional communities of multiple stakeholder groups sharing the responsibility of educating, supporting and retaining the Cal Teach students (Newton et al., 2010, p. 23).

Integration of the various aspects of the Cal Teach program is a piece the researchers find to be particularly interesting, noting that all of the experiences included in the program "inform, build on, and support each other" (p. 24). Other elements of Cal Teach Newton et al. highlighted include the inquiry approach to educating taught in the program and the full year job-embedded training in which students work full time in schools as teachers of record. These internships are coordinated mainly through three local urban school districts, enabling Cal Teach students to better understand the need for highly qualified science and mathematics teachers in urban schools. To further clarify this need, students are required to take a course focused on mathematics and science equity as it relates to urban schools:

> This course concerns the historical, economic, political, and legal foundations that frame many of the equity challenges in our public schools. It examines the opportunity and achievement gaps that separate urban youth from their peers in non-urban/suburban schools, especially in the subject areas of mathematics and science. It also examines current conditions and measures of equity. It concludes with a close-up view of schools that, despite the odds, are making a difference for students of color and students in poverty. (Newton et al., 2010, p. 27)

The emphasis on urban education and integration of all aspects of the teacher preparation program make the Cal Teach program noteworthy as an exemplary STEM teacher development program; still active at UC Berkeley at the time of this study.

Teacher Preparation Programs

Bezuk and Chiero (1997), in their article "Preservice Teacher Preparation in the United States," noted that diversity of programs throughout the country makes it difficult to describe domestic teacher preparation as a whole. The authors noted that teacher preparation programs tend to fall into two categories: traditional four year undergraduate path and the alternative teacher credential path that developed from a need for more teachers (Bezuk & Chiero, 1997). Four year undergraduate teacher preparation programs typically include general education, coursework preparing the student in the content area they wish to teach, multiple education classes, and field experience teaching classes in an actual school (Bezuk & Chiero, 1997).

Alternative teacher credential pathways are usually designed to support college graduates working as teachers who have not had formal training or preparation. These supports often include coursework through local colleges or the school district itself, involvement in new teacher induction programs, and participation in a mentoring relationship with a veteran teacher (Morey et al., 1997, pp. 10-12).

Research by Evans (2010) considered whether teachers who enter the profession through traditional teacher preparation programs in universities and colleges have different understandings of their occupation than teachers who enter the profession through alternative certification programs. To answer this question, Evans interviewed 49 beginner teachers—23 from traditional teacher preparation programs and 26 from alternative certification programs (p. 183). The majority of these teachers (n = 28, 57%) were employed in an urban school district, 11 in a rural school district, and 10 in a suburban school district (p. 190). As the researcher expected, the themes of the interviews with teachers centered on "coursework, professors and

instructors, and experiences in the classroom context, all of which shape the understandings of the occupational role for novice workers" (Evans, 2010, p. 191).

Overall, traditionally prepared teachers appeared to be less satisfied with their teacher preparation than the teachers who participated in alternative certification programs. Teachers who graduated from schools of education viewed their coursework as being on a sliding scale of usefulness; from classes they deemed poor—focused on historical aspects of education, to the classes the teachers felt had been excellent preparation—typically in their content area. Teachers felt that the pedagogy classes they completed were the "most important in the preparation and in the occupation," separating those who can teach from those who cannot (Evans, 2010, p. 193).

The teachers who participated in alternative certification programs, on the other hand, believed that their programs were challenging and practical:

> The majority of AC teachers stressed how good the instructors were, how relevant the material was, and how the intensity of the program motivated and inspired them. Teachers typically reported that, "They really prepared us at the preparation program. I mean the two weeks, from 8-4, was really packed with stuff and I would go home exhausted". (Evans, 2010, p. 195)

Evans concluded that teacher preparation, whether through traditional methods or alternative certification programs, should include a strong focus on the classroom to be most helpful (p. 202).

Alternative Certification Programs

Friedrichsen, Abell, Pareja, Brown, Lankford, and Volkmann (2009) considered alternative certification programs and the role prior teaching experience played in the development of teacher knowledge. "In particular, we wanted to test the notion that teachers learn what they need on the job, by comparing the prior knowledge of two different types of

ACP teachers—those with and without prior teaching experience" (p. 358). The authors believed understanding this information would better inform the teacher education community and equip them to produce greater numbers of highly qualified science teachers. They concluded their findings challenged the idea behind alternative certification; teachers who are prepared with pedagogy will pick up the content area knowledge along the way. The science teachers they examined who had previous teaching experience "did not differ significantly in their teaching knowledge compared to the interns" (Friedrichsen et al., 2009, p. 377). However, it should be noted that this research was only conducted using four teachers—two interns and two teachers with two years of prior teaching experience. In order for the data to be useful and generalized to all alternative certification programs or even to all alternative certification programs that produce science teachers, this study would need to be replicated with a larger sample.

Simmons (2005) sought to understand the motivations of teachers who successfully completed an alternative certification program. Eighteen interviews were conducted using a qualitative approach to consider aspects of their personalities and backgrounds including gathering a general understanding of who they were, their motivations for switching careers, and how they approached learning to teach (Simmons, 2005). With little or no formal course work in pedagogy, the approach to learning they used that enabled them to be successful is of great interest. Teachers will continue to move into the field using alternative routes, and being well informed regarding successful alternatively certified teachers' approach to learning will enable school districts and other providers to design programs to include the most important elements that allowed these teachers to be successful (Simmons, 2005, p. 36).

While the most frequently noted motivation for becoming an educator was making a difference in the lives of children, several secondary motivators were observed. Many teachers shared that time played an important role in their decision. Over 50% addressed the benefits of the schedule traditionally followed by teachers, including a reluctant acknowledgment that having summers off was an added incentive (Simmons, 2005, pp. 37-38). They also appreciated the ability to learn from others, typically in mentoring relationships. The teachers believed that "the opportunities they had to observe other teachers and to be observed were very helpful in refining their teaching skills" (Simmons, 2005, p. 40). Their appreciation for this opportunity was coupled with the reflection that the mentoring relationships were not perfect, and would have benefitted from having more time to observe or meet with each other.

Simmons also noted that while a good deal of research exists documenting ways to support teachers in alternative certification programs, insufficient credit is given to the experiences and unique skills these teachers bring to their positions. Several teachers who participated in the study had prior experience training or giving presentations that they related to their teaching roles; whether through operating as a corporate trainer or training soldier while in the military. The author believes that these strengths should be considered when developing professional learning for them (Simmons, 2005, p. 41). At the same time, however, Simmons acknowledged that each teacher participating in the study had a unique background. It might be impractical for a school district to design an alternative certification program that considers the unique backgrounds of hundreds or even thousands of teachers.

Simmons also observed that it appeared there was "an emphasis on the subject-area test results rather than a systematic review of the candidate's skills, abilities, pedagogical

foundations, and general disposition for teaching" (Simmons, 2005, pp. 42-43). Further research was suggested in the area of mentoring, specifically the importance of it for those who have not completed student teaching (such as alternative certification teachers). Simmons acknowledged that numerous studies have examined mentoring in traditional teacher preparation programs, but concluded that understanding the significance of mentoring for alternative certification teachers would be useful (Simmons, 2005, pp. 43-44).

To truly compare the impact that various teacher preparation programs have on the development of teachers, Beare, Torgerson, Marshall, Tracz, and Chiero (2012) analyzed whether there were "clinical and statistically significant differences in the effectiveness of three pathways to teacher preparation on a single campus" (p. 56). These pathways were designed for both preservice teachers and teachers working full-time who needed to complete an alternative certification program. Effectiveness was not determined based on improved student achievement, but rather ratings from the graduates of the quality of preparation they received, determined at the end of their first year of teaching professionally. The three pathways utilized in this study were identified as Yosemite Campus-Based (YCB), Yosemite Internship (YI), and Yosemite Partner School Program (YP). The researchers described YCB as a traditional preparation program for teachers; students participated in evening classes held on the university campus. They were not part of a cohort and could take classes part-time over multiple semesters. Field work was typically completed in multiple schools or school districts, and the students usually had different supervisors and instructors each semester (Beare et al., 2012, pp. 61-62).

YI Participants were interns who attended classes in the evening on the university campus. They did not have a separate group of classes from the YCB students, instead they

joined them in the YCB classes. The researchers described them as "a fluid cohort in that they had the support of one dedicated full-time faculty member/director and five part time faculty who met with them at monthly weekend seminars" (Beare et al., 2012, p. 62). They participated in the program while employed either part-time or full-time as teachers, and worked with site-based mentors who typically also taught classes. Participants in YP earned their credentials as part of a closed cohort and were assigned to a particular school district partner:

> University coursework was completed onsite in a dedicated classroom at a partner school and fieldwork experiences were completed in classrooms in the partner district. The university and participating districts served as partners striving to affect student learning, educator preparation, professional development, curriculum development, and research inquiry. (Beare et al., 2012, p. 62)

The prospective teachers engaged in the same professional learning activities as the school district faculty throughout the year and spent one day participating in team building on a ropes course. The researchers analyzed seven years of data produced by teachers completing the various Yosemite State programs. This included examining survey responses from 599 teachers who completed the programs and 425 employment supervisors of those teachers. The researchers concluded that "no significant differences were found among the ratings of the employment supervisors, however teachers identified substantial differences despite all groups enrolling in the same courses taught by the same pool of instructors using a common master syllabus" (Beare et al., 2012, p. 67). Teachers who graduated from the Yosemite Partner School Program rated their experiences superior in every aspect to the other programs, with all of the differences scoring as statistically significant. These findings indicate that the aspects that make YP unique from the other programs should be incorporated when possible into teacher preparation programs. The researchers indicated a need for further study of this topic, citing the

limitations of having examined preparation programs in only one university setting (Beare et al., 2012, p. 71).

Innovative Teacher Preparation Programs

While these are the two most frequently seen methods of preparing teachers, a desire exists in some areas to develop new and better ways of preparing teachers. One such program, the Mathematics Community Continuum (MCC), attempts to use mathematics education in a charter school (described by the authors as an urban mini-district) as a way to study teacher development and learning (Benken & Brown, 2008). The MCC tried to do this through:

> a reciprocal community using multi-level mentoring, site-based professional development, shared expertise, and research to facilitate teacher growth and learning of prospective and practicing teachers, school administrators, and university faculty. (p. 63)

In their article, the authors addressed several ways in which the structure of the program helped advance the student learning of mathematics and the teaching of mathematics (Benken & Brown, 2008, p. 63).

The MCC was a collaborative effort between a college of education, a mathematics department, and a charter school. Participants in the community came from five main groups: prospective future teachers or interns, current elementary school teachers, current high school teachers, school administrators, and researchers/university faculty. The researchers created the program using highly regarded educational practices as a response to "this school's history of low student achievement and our Nation's promise of a Highly Qualified teacher in every classroom, particularly in mathematics" (Benken & Brown, 2008, p. 68). The researchers consider the key components of the MCC to be: collaboration among stakeholders focused on improving students' achievement and performance on high-stakes tests; attention to intellectual

and emotional support of the community; bi-monthly professional learning to improve general pedagogy, content knowledge, and understanding of implementing reform curricula; differentiation for both students and teachers; mentoring partnerships; summer workshops; and both guided and open-ended reflection (Benken & Brown, 2008, p. 69).

The researchers collected data for several years including interviews with administrators and teachers, field notes from classes offered to the community, participant reflection journals (which the researchers kept as well), surveys examining teacher knowledge and beliefs (completed both pre- and post-), and artifacts from teachers. The data were analyzed using direct interpretation to gather overall themes, aggregated to identify trends within constituency groups such as teachers, and analyzed across constituents to discern "in what ways the structure of the continuum helped to advance the learning of mathematics and its teaching, as well as the possible impact on long-term growth and quality of evidence of value-added role in student learning" (Benken & Brown, 2008, p. 71).

The results of these analyses demonstrated that the participant elementary teachers learned the most mathematics related material. The researchers also determined that findings of previous researchers related to mathematics anxiety (which includes symptoms such as "uneasiness or inability to perform mathematically, avoidance until the last possible moment, and feelings of physical illness, faintness, dread, or panic,") were accurate, adding that mathematics anxiety does exist in preservice teaches and current teachers, and it influences their practice (Benken & Brown, 2008, p. 73). Administrators and teachers alike garnered a better understanding of designing effective instruction rather than utilizing a premade lesson plan. They also grew in their knowledge of collaborative planning. The researchers concluded that the

model should serve as "an exemplar of how to design university-school partnerships that move traditional programs beyond the limiting barriers of exiting roles and isolated efforts" (Benken & Brown, 2008, p. 80).

Green and Ballard (2011) detailed another teacher preparation program, the Professional Development School, which provides a "transformative learning experience" (p. 12) for participants. Preservice teachers in this program experience learning that has been strengthened and enriched through "application of experiential and adult learning theory" (Green & Ballard, 2011, p. 12). Utilizing this approach may lead to learners with increased capacity to reflect, greater self-direction, and improved meta-cognitive abilities.

The Professional Development School offers a different path from the traditional model of teacher preparation. It begins with a formal partnership between a university and a school district, with both agreeing to provide the resources, context and expertise needed for the project. The university selects a faculty member to serve as a liaison between them and the school district, overseeing all activities of the program, assisting with supervision of interns, at teaching classes at the Professional Development School site. The liaison then collaborates with PDS teachers and university staff to design a standards-based curriculum. Toward the end of their sophomore year, prospective students submit applications to the program (Green & Ballard, 2011, p 13).

During the senior year of the program, students are engaged in dual roles as university students and professional employees of the school district. The interns complete nine credit hours per semester, and participate as a member of a team of teachers at a local school under the tutelage of a Master Teacher (MT). They are an integral part of the team from the first day of

pre-planning in August through the last day of post-planning in June, receiving an annual salary similar to a paraprofessional and the benefits afforded the master teacher (Green & Ballard, 2011, p. 13).

The researchers outline the collaborative effort between the master teacher and the PDS liaison as they work to provide rigorous and authentic learning experiences for the interns:

> MTs are considered university adjunct faculty members and teach university-level courses that support the teacher intern experience; each MT also conducts a professional development seminar for PDS participants… These two members plan scope, sequence, and delivery of all course content and imbed content into the classroom for TI practice. (Green & Ballard, 2011, p. 13)

This Professional Development School operated in Texas, used a team teaching strategy with one Master Teacher (MT) and two Teacher Interns (TI) per class of 40 students. The program was in its sixth year at the time this article was written, and had produced 62 preservice teachers—all of whom successfully passed all aspects of the state certification exams. It has been adjusted each year as a result of conversations focused on "intern scores from the state licensure exams, standardized test scores of the classroom students, ratings of professionalism and competency on standard referenced tasks, and final course grades" (Green & Ballard, 2011, p. 16).

The Professional Development School has led to tremendous improvement in student performance on standardized tests each year from the initiation of the program (2004-2005) through the 2009-2010 school year. The researchers described the gains:

> …baseline assessment values for that year were: Reading 81%, Math 87%, Writing 87% and Science 43%d. Assessment values reported in 2009 were: Reading 95%, Math 91%, Writing 100%, and Science 80%. Assessment values dropped this past year, for unknown reasons as of this time. (Green & Ballard, 2011, pp. 16-17)

The impressive growth on these tests coupled with the top-notch quality of the teachers produced through the Professional Development School has led to high praise for the program.

It has gradually come to be seen as more of a viable teacher preparation path by university faculty and school district personnel. Though there have been some challenges such as traditionally trained teachers throughout the school district resenting those trained by PDS and a great deal of stress falling upon the Master Teachers, the PDS seems to have been very successful. The researchers attribute this to four factors, "all hallmarks of adult learning theory and practice: Ownership, Modeling, Teamwork, and Application of Course-Based Pedagogy" (Green & Ballard, 2011, p. 18).

Lesson Study

Beginning in Japan in the 1900s, lesson study is a professional learning technique involving collaborative planning and reflection among teachers. The strategy became popular in the U.S. in the late 1990s. The purpose of lesson study is not the development of a perfect lesson, but rather to improve the capabilities of teachers as reflective practitioners. The practice includes four steps: examining the curriculum/unpacking the standards and developing goals, planning the lesson, teaching the lesson (known as the research lesson), and collaboratively reflecting upon the instruction and student reaction to the research lesson (Lewis & Hurd, 2011, p. 2). Lesson study has been shown by numerous studies to have benefits for teachers (Lewis et al., 2011; Robinson & Leiken, 2011; Sims & Walsh, 2009).

In "Lesson Study and SIOP Help Teachers Instruct ELLs," Honigsfeld and Cohan (2008) state that lesson study contributed to teachers' ability to "provide effective instruction for ELLs in mainstream classrooms" (p. 24). Their study involved a group of teachers participating in an Intensive Teacher Institute (or ITI) in a high-needs school district in New York. Teachers were eligible for this program if they taught a high percentage of ELL students but had not received

thorough training in this area. These teachers participated in lesson study centered on the eight major principles of Sheltered Instruction Observation Protocol (SIOP), preparation, building background, comprehensible input, strategies, interaction, practice/application, lesson delivery, and review/assessment (Honigsfeld & Cohan, 2008, p. 25).

The researchers wanted to know two things: How the data gathered on SIOP lesson study showed participants' skills, dispositions, knowledge, along with their impact on students; and the general outcome of this model of professional learning that combined SIOP and lesson study (Honigsfeld & Cohan, 2008, p. 26). They concluded that student artifacts demonstrated the model was effective:

> Students used graphic organizers and scaffolded tasks and showed examples of growth through writing samples. From a collection of student artifacts, we knew that the implementation of the SIOP model was not only effective, but also that the work sparked the creativity of the students. (Honigsfeld & Cohen, 2008, p. 26)

They added that although the teachers acknowledged that lesson study was quite time consuming, they determined it to be some of the most impactful professional learning they had ever been a part of as both their teaching and reflecting skills and their knowledge base increased. The researchers determined, therefore, that "a combination of the lesson study and SIOP models will greatly enhance teaching and learning focused on ELLs" (Honigsfeld & Cohan, 2008, pp. 26-27).

Lesson study was also used in an attempt to examine the attitudes and beliefs of teachers regarding inclusion, the efficacy of teachers, and the idea of moderate learning difficulties. Ylonen & Norwich (2012) set out to determine whether or not lesson study could be used to improve the opportunities and learning experiences of students with disabilities. Thirty-four teachers from fourteen different schools in England participated in the study. Two teachers of

English, the humanities, and/or the arts engaged in the lesson study program throughout the course of two semesters (from November 2010 through July 2011). Of the 14 schools that participated, ten completed three full cycles of lesson study and four completed two full cycles. The researchers examined both quantitative and qualitative data including: a survey analyzing the attitudes and beliefs of teachers; a second survey focused on teaching strategies that had been utilized and developed throughout this study; case study reports completed by the teachers as they participated in lesson study; and interviews conducted with nine of the participating teachers (Ylonen & Norwich, 2012, pp. 304-305).

The researchers' findings regarding efficacy indicated that most teachers believed that they could, with effort, reach most challenging students and that they were equipped to be effective teachers by their training and experiences. However, the teachers were not sure that they could attribute abnormal student progress to their efforts, and they disagreed with the statement that they had received ample training to successfully deal with learning problems. The teachers also agreed with the statement that inclusion is vital and felt their current schools of employment were inclusive. There was, however, very little consensus regarding various aspects of moderate learning difficulty (MLD) students such as whether or not learning challenges identified as MLD should be considered intellectual disabilities (Ylonen & Norwich, 2012, pp. 306-307).

The most frequent outcome of the lesson study process mentioned in the case reports and discussed in the interviews was a change in focus from teaching and teacher, to students and student learning:

> For example, one teacher commented that as a result of the process she had adopted a student focused approach, which meant that students were increasingly given 'ownership

> of their own learning and time to reflect on what they have done'. (Ylonen & Norwich, 2012, p. 312)

Participating teachers also expressed an appreciation that lesson study had helped them identify several behaviors that students with disabilities were using to hide their difficulties, such as rushing to complete their work and copying. Teachers also indicated that participating in lesson study had revealed to them a need to diversify the activities they use to engage students in learning (p. 312). The researchers concluded that lesson study was beneficial for the teachers as it "enabled teachers to develop a renewed enthusiasm and interest in various aspects of their teaching practice as well as provide them with new skills, new insights and a vision of new possibilities" (Ylonen & Norwich, 2012, p. 315).

Lesson Study and Preservice Teachers

As lesson study has grown more popular in recent years it has been utilized more frequently as a component of preservice teacher preparation. In "Lesson Study with Preservice Teachers," McMahon and Hines (2008) described their experiences implementing lesson study with preservice mathematics teachers at the secondary level. The authors engaged eight preservice teachers in one full lesson study cycle. Statements made during a post-lesson study debriefing session with the preservice teachers indicated that lesson study can be a powerful tool due to several factors: as a lesson planning tool, the process systematically improves the quality of instruction; the process guarantees that teachers receive relevant and timely feedback related to their instruction; the common goal of improving learning removes any concerns single teachers may have about being personally evaluated; and collaborating for lesson study allows teachers to receive recognition of their efforts and professional knowledge from their peers (McMahon & Hines, 2008, p. 190).

Cohan and Honigsfeld (2007)also conducted a study on using lesson study as part of teacher preparation for both undergraduate and graduate students. Their study included 51 graduate students and 17 undergraduate students. They attempted to answer three questions: what is the effectiveness of lesson study in teacher education courses; what benefits are gained by using lesson study in teacher education courses; and what differences are there in using lesson study in graduate versus undergraduate courses? While the graduate students followed the traditional lesson study method of engaging in the four steps as a group, it should be noted that the undergraduate students planned and taught their lessons individually, videotaping them for later viewing and discussion by the other students (pp. 80-83). The researchers examined reflections completed by the participating students and concluded that lesson study was valuable. Students stated in their reflections that lesson study helped them develop as teachers, impacted their students learning, and provided them with new pedagogical skills despite frustration with some group members' poor participation. Stated benefits also included improved self-efficacy and a better understanding of culturally diverse students such as English language learners. Graduate students enjoyed additional benefits as they were able to learn from their peers' strong content knowledge which would not be present in undergraduate students (Cohan & Honigsfeld, 2007, pp. 86-87).

Gaps in the Literature

While a great deal of research has been conducted on teacher preparation programs, including traditional programs completed at universities and colleges, alternative certification programs completed by teachers who did not earn undergraduate teaching degrees, and unique teacher preparation programs, gaps in the literature still exist. Most notably, no research could

be found examining the correlation between teacher preparation programs and student performance on standardized tests. Although any such research would be hard to generalize—all schools are different, teachers bring diverse backgrounds with them, and students in one state take entirely different tests than students in others—data examining the big picture of how the students of teachers from traditional preparation programs perform on standardized tests compared with how students of teachers from alternative certification programs perform on these tests would shed an informative light on the discussion.

Similarly, there remain several areas of lesson study that have not been sufficiently studied. Lesson study is most often explored at the elementary level, and more data and analysis should be conducted at the secondary level. Although multiple studies have demonstrated numerous benefits of lesson study, there remains a dearth of research correlating the use of lesson study with improved test scores or other measures of student achievement. Research should be conducted in this area to examine whether greater gains in student learning can be added to the ever-growing list of bonuses to implementing lesson study.

Summary

This literature review began by outlining how the search was conducted, discussing key words used and databases searched. A review of the literature was then presented. This review included research regarding the shortage of STEM teachers along with recruitment and retention efforts. Research related to teacher preparation programs was also presented, including traditional teacher preparation programs, alternative certification programs, and innovative teacher preparation programs. A review of research related to lesson study followed, including

how lesson study has been used with preservice teachers. Finally, an outline of gaps in the literature was presented. In the next chapter, the methodology of the study will be explained.

CHAPTER 3
METHODOLOGY

Introduction

This study was conducted to examine lesson study as a model of collaborative reflective practice for continuous improvement. STEM graduates entering education need such a model to support their growth and learning as new secondary school teachers. While the cyclical nature of lesson study makes it a natural fit for continuous improvement, little research into its effectiveness as a tool for new teacher preparation exists. This research was conducted with the following questions as the focus: What is the lesson study model of each of the three sampled RTP^3 partner school districts? To what extent did partner school districts modify lesson study implementation as a result of participation in RTP^3? Lastly, to what extent do the sampled RTP^3 resident teachers perceive that lesson study assisted them in improving teacher effectiveness?

Selection of Participants

The population of this study was all of the 103 resident teachers from each of the five partner school districts in the RTP^3, previously identified as School Districts A, B, C, D, & E. However, the entire population of the study is not included in the study sample. Convenience sampling was used as all RTP^3 resident teachers from School Districts A, B, and E whose reflections were available for analysis were included. The lesson study reflections of some teachers in School Districts A, B, and E were unavailable, and resident teachers from School Districts C and D were removed from the sample (as there were only about three per school district in each cohort). As the reflections were coded to maintain the anonymity of the teachers, two descriptors of gender and courses taught were used to describe the participants in the sample.

Table 3 shows the population of the study categorized by cohort and subject area along with how many reflections were available:

Table 3

*Population of Resident Teachers from Sample School Districts and Sample Teachers Matched by Content Area Taught (*N *= 37)*

School District	Content Area Taught	Cohort 1	Cohort 2	Included in Sample
A	Biology	8	9	6
	Chemistry	2	3	0
	Chemistry/Physical Science	0	2	0
	Geometry/Statistics	0	1	0
	Life Science	0	3	0
	Marine Biology	0	1	0
	Mathematics	0	7	1
	Middle School Mathematics	0	1	0
	Physical Science	0	2	0
	Middle School Science	2	3	1
	Physics	1	2	2
	Science	1	0	0
B	AP/Gifted Biology	1	0	0
	Biology	1	2	2
	Chemistry	0	4	3
	Earth/Space Science	1	0	0
	Geometry/Algebra	1	0	0
	Life Science	1	0	1
	Mathematics	2	4	5
	Middle School Mathematics	0	1	1
	Middle School Science	0	2	2
	Physics	3	2	4
	Science	0	1	0
E	Algebra 2	1	2	1
	Algebra 1	1	0	1
	Biology	6	1	4
	Chemistry	1	1	1
	Geometry	0	2	1
	Physics	0	1	1

Instrumentation

The primary data analyzed in this study were generated through two means: interviews of school district designees by the author of this study and reflections of RTP^3 resident teachers. In some instances these reflections were specific to lesson study, and in other instances they were reflections on teacher work samples that resulted from lesson study and that mentioned lesson study or elements of lesson study such as collaboration. School District E changed their method of lesson study reflection from individual to team reflections for Cohort 2. The instrument used for the partner school district designee interviews consisted of five items developed by the author of this study with the assistance of Dr. Rosemarye Taylor, the principal investigator of the RTP^3 (and chair of this dissertation). The interview items are presented in Appendix A. They were designed to draw out the differences among the three school districts' lesson study models and implementation.

Data Collection

Prior to collecting any data, the five interview items were developed and the proposal for the study (including the interview items) were submitted to and approved by the University of Central Florida's Institutional Review Board. Resident teachers submitted their lesson study reflections to their job-embedded two semester UCF intern coordinator and uploaded the reflection as a required teacher work sample. The work sample was to include a lesson design, student data analysis, and a reflection related to the effectiveness of the lesson and what was learned from the lesson study experience. The researcher analyzed only the reflection of the lesson study component and not the lesson study design itself. The UCF intern coordinator

forwarded lesson study reflections to the RTP³ principal investigator who provided them to the researcher once approval had been obtained from the UCF IRB. The resident teachers' reflections were assigned an alphanumeric code. The resident teachers' names and schools were not identified nor tied to their reflections. The reflections were identified only by the teacher's gender and subject area taught.

Table 4

Lesson Study Reflection Descriptors and Alphanumeric Codes

Cohort	School District	Content Area	Gender	Alphanumeric Code
1	A	Biology	Female	Female Biology A.1.1
		Biology	Female	Female Biology A.1.2
		Biology	Female	Female Biology A.1.3
		Biology	Female	Female Biology A.1.4
		Biology	Female	Female Biology A.1.5
		Biology	Male	Male Biology A.1.1
		Middle School Science	Female	Female Middle School Science A.1.1
		Physics	Male	Male Physics A.1.1
	B	Biology	Female	Female Biology B.1.1
		AP/Gifted Biology	Female	Female AP/Gifted Biology B.1.1
		Life Science	Male	Male Life Science B.1.1
		Mathematics	Female	Female Mathematics B.1.1
		Physics	Female	Female Physics B.1.1
		Physics	Male	Male Physics B.1.1
	E	Algebra 1	Female	Female Algebra 1 E.1.1
		Biology	Male	Male Biology E.1.1
		Biology	Male	Male Biology E.1.2
		Biology	Female	Female Biology E.1.1
2	B	Mathematics	Female	Female Mathematics B.2.1
		Mathematics	Female	Female Mathematics B.2.2
		Mathematics	Female	Female Mathematics B.2.3
	E	Algebra 2	Team	Algebra 2 Team E.2.1
		Biology	Team	Biology Team E.2.1
		Chemistry	Team	Chemistry Team E.2.1
		Geometry	Team	Geometry Team E.2.1
		Physics	Team	Physics Team E.2.1

Interviews were conducted with the three partner school district designees from School District A, School District B, and School District E. Prior to the interviews being conducted, each partner school district designee was sent the IRB approved Informed Consent Letter (see

Appendix B). The first interview was conducted with the designee from School District A. This was a phone interview conducted August 20, 2014 at 7:45 p.m., and it lasted approximately 15 minutes. The second interview was a phone interview with the designee from School District E conducted August 26, 2014 at 2:25p.m., and lasting approximately 10 minutes. The third interview with the designee from School District B was conducted in person at her place of work on October 3, 2014 at 8:15 a.m. and lasted approximately 10 minutes.

Data Analysis

The artifacts, resident teachers' reflections, and interviews were analyzed using the constant comparison method (Parry, 2004). The primary artifact examined was the RTP^3 lesson study model. The analysis consisted of reading the lesson study model four times on separate occasions and becoming familiar with the essential and recommended components prior to interviewing the school district designees.

After reviewing the RTP^3 lesson study model, including an examination of the essential and preferred components of lesson study, the specific lesson study models of each school district were explored during interviews with the three partner school district designees. Interviews were analyzed to determine differences in the implemented lesson study models of each school district. While all three school districts stated they used the RTP^3 lesson study model, each school district implemented the model differently, with school district designees mentioning the importance of different components in their contexts.

The resident teacher lesson study reflection and teacher work sample reflection analysis process included reading all reflections once to get an initial understanding of apparent themes and trends. Reflections were then read again for the purpose of documenting every sentence

related to lesson study in a series of tables. These tables can be found in Appendix D, Appendix E, Appendix F, Appendix G, and Appendix H and include each resident teacher reflection, identified by alphanumeric code, along with every sentence related to lesson study, organized by school district and reflection type. The sentences related to lesson study found in these tables were then closely analyzed for patterns and trends, and another table (Table 7) was created. Table 7 identified any theme that was included in more than one resident teacher reflection, and contained the theme, frequency with which it occurred, and alphanumeric code of the reflection that referenced the theme. The table was examined to determine the themes that occurred most frequently. Once the themes that occurred most frequently were identified, additional tables were generated specific to each frequently occurring theme. These tables included every quote from any resident teacher reflection that addressed the specific theme on which the table was focused, identified by alphanumeric code. The information in the tables led to the findings of this research study as outlined in Chapter 4.

Summary

The chapter began with a review of the statement of the problem and the research questions that were used to guide this study. Then there was a discussion of the selection of participants in the study. Instrumentation was addressed relating to the interview questions prepared for the school district partner interviews. Methods used to collect data were described, including both artifacts collected and interviews conducted. Finally, there was an explanation of the data analysis methods used to examine the data collected throughout this study. The findings of this data analysis will be addressed in the following chapter.

CHAPTER 4
PRESENTATION AND ANALYSIS OF DATA

Introduction

The problem to be considered in this study was that secondary STEM graduates who come into education need a model of collaborative reflective practice for continuous improvement. Lesson study is one possible model of professional learning that is both reflective and collaborative (Sims & Walsh, 2009, p. 731). The cyclical nature of lesson study makes it a natural fit for continuous improvement. However, as little research into the effectiveness of lesson study as a tool for new teacher preparation or for middle and high school teachers exists, an examination of lesson study as the model of collaborative reflective practice for continuous improvement was both appropriate and necessary.

The purpose of this study was to determine the extent to which participation in a lesson study research team was perceived to have an impact on teacher effectiveness. The purpose of this study was achieved by examining the lesson study models of the three sampled RTP^3 partner school districts and analyzing all available lesson study reflections and teacher work sample reflections from both cohorts of resident teachers.

The research questions used to guide this study were: What is the lesson study model of each of the three sampled RTP^3 partner school districts? To what extent did the sampled RTP^3 partner school districts modify lesson study implementation as a result of participating in RTP^3? To what extent do RTP^3 resident teachers perceive that lesson study assisted them in improving teacher effectiveness? The results of the data analysis for the research questions are presented in this chapter.

Research Question One

What is the lesson study model of each of the three sampled RTP^3 partner school districts?

School District A

School District A is a large, urban school district in Central Florida serving about 180,000 students. Prior to participating in RTP^3, School District A had implemented lesson study district-wide as a requirement of Race to the Top. The School District A designee indicated that for RTP^3 lesson study, they incorporated all of the requirements discussed in the RTP^3 lesson study essential model (see Appendix I), including lesson study research teams collaborating, planning together, collecting data on students, analyzing that data and reflecting on it, and using a knowledgeable other.

The primary lesson study model of School District A involved grouping resident teachers with their professional learning community (PLC) and their mentors. When it was not possible to use this model due to low numbers of teachers at a school in a specific content area, they brought teachers together from different schools. This typically involved a mentor from a different school joining the content area team, or content area teachers (such as physics) from various schools collaborating as there are rarely multiple high-level mathematics and science teachers in one high school. When mentors came from different schools, they were able to bring their expertise or resources that the other schools may not have had. For example, on one of the marine science teams, the two veteran teachers on the team had not taught marine science before, so the course was new for everyone. The mentor teacher was able to help the entire team, even the veteran teachers. She also brought resources, such as sponges, that were needed to teach the content when the other teachers did not have any.

An aspect of the RTP^3 lesson study model that the designee from School District A found to be exceptionally valuable was the inclusion of a Knowledgeable Other from the university. In this instance, the Knowledgeable Other was a brilliant mathematics professor from a local university. The school district designee repeatedly emphasized the value of the input of Dr. Erhan Selcuk Haciomeroglu, UCF Associate Professor of Mathematics Education.

> One of the teams was looking at problems that you selected for kids based on your intent for learning. With very few questions he was able to help them with choosing problems that hit more than one math concept. The other team he helped to understand a foundational concept of angles that they really missed with the kids. They went straight into looking at angles and sides and it came out that they didn't know themselves why this worked. So he was able to help them understand that and see the need of explaining that to kids before launching into deeper content with them. (School District A Designee, 2014)

School District B

School District B is a medium-sized, suburban school district in Central Florida serving about 65,000 students. The School District B designee also indicated that they used the lesson study model developed by RTP^3 (Appendix I). While the school district lesson study model incorporated many elements of the RTP^3 lesson study model, there were some differences. One notable difference was in the first year it was necessary to create teams of teachers from different schools, as schools did not want to participate. These teams were not only from schools across the school district but they were teams of teachers from different content areas as well. The school district designee indicated that these teams were necessary and done "just to get the people through the program" (School District B Designee, 2014). The designee expressed frustration with the level of participation offered from the schools, adding that she "felt it was a waste of time and energy" to participate in lesson study without adhering fully to the agreed upon model.

School District E

School District E is an internet-based public school district serving over 140,000 students in half-credit enrollments. According to the school district designee, School District E had not participated in lesson study prior to RTP^3. As it is a virtual school district, the model was unique. In the first year of RTP^3, there were five lesson study teams grouped by subjects taught and consisting of both resident teachers and mentors. Four of the teams started out by meeting face to face to plan the lesson. A fifth team was completely virtual and planned their lesson online. All of the teams delivered their instruction virtually as that is how their students receive instruction. Once instruction was complete, all five of the teams' remaining meetings (including the data analysis meeting) were held online. These meetings were held using Blackboard Collaborate, and helped School District E realize that collaborating in this manner was successful and effective. This realization led the school district to conduct all five lesson study groups in the second year of RTP^3 completely online.

Research Question Two

To what extent did the sampled RTP^3 partner school districts modify lesson study implementation as a result of participating in RTP^3?

School District A

As a result of participation in RTP^3 and implementation of the RTP^3 lesson study model, the School District A designee indicated that the experience led School District A to examine previously held beliefs. For example, the school district became open to the idea of cross-content teams and doing lesson study in a day, where previously they did not have cross-content teams and lesson study consisted of two half-day sessions. The concept of the university

Knowledgeable Other also made an impact on the school district, leading them to value those academic contacts that might be able to participate in this manner, along with considering how they could incorporate the Knowledgeable Other into their lesson study teams on a more consistent basis.

School District B

Results of participation in RTP^3 and implementation of this lesson study model for School District B were minimal, perhaps based on the lack of full participation of all schools as mentioned by the school district designee. The school district did not modify its lesson study model at all based on the experience of participating in RTP^3, and the school district designee added that she was not aware of lesson study occurring anywhere in the school district now that RTP^3 has ended.

School District E

As a result of these successful lesson study sessions, School District E has expanded lesson study throughout the school district. The school district designee indicated that participating in lesson study through RTP^3 gave them the necessary knowledge to be able to implement lesson study. The designee added that School District E is even "developing an online intro to lesson study course and a virtual facilitator course that will be able to be used in the future" (School District E Designee, 2014).

Table 5 contains a summary of each partner school district designee's response to the five interview items (Appendix A). The designee responses to the interview items informed the findings for research questions one and two. While some trends emerge in this data (such as both School District B and School District E primarily participating in RTP^3 out of a desire to

recruit STEM teachers and School District A and School District B believing that they were following the RTP^3 lesson study model), it is difficult to link any findings to trends in these answers.

Table 5

Summary of Partner School District Designee Interview Responses

School District	Reason for Participation	School District Lesson Study Model	Lesson Study Prior to RTP^3	Evidence of Participation	School District Changes
A	Wanted to better support STEM teachers who were non-education majors	Followed RTP³ Lesson Study Model, with some cross-district/same content area teams and an emphasis on including a knowledgeable other	Had not previously used cross-district teams, completed lesson study in a single day, or focused on the role of the knowledgeable other	Used a sophisticated tracking system, kept attendance and evidence from each cycle, and participants completed a three question survey	Became open to the idea of cross content teams & completing lesson study in a day, along with considering additional ways to incorporate the knowledgeable other
B	Wanted to recruit STEM teachers	Followed RTP³ Lesson Study Model, with some cross-district/same content area teams	Schools did not want to participate in lesson study	Collected data from each lesson study cycle including resident teachers' observations	None that the designee was aware of, school district designee unsure if lesson study is still being used
E	Wanted to recruit STEM teachers	Lesson study was mostly conducted online with same content area teachers	Lesson Study had not been attempted prior to participation in RTP³	Attendance was taken and a survey was given asking what went well, what was learned, and what could be improved upon	Lesson study has been expanded district-wide & online Intro to Lesson Study and Virtual Facilitator courses are being developed

Research Question Three

To what extent do RTP^3 resident teachers perceive that lesson study assisted them in improving teacher effectiveness?

Nine of the 37 resident teacher reflections analyzed (24%) indicated that participation in lesson study had improved their effectiveness or helped their growth as a teacher. This growth was usually stated as either an overall claim of improvement as a teacher due to participation lesson study or the identification of specific skills related to teaching that improved thanks to participation in lesson study. Male Biology Teacher A.1.1 for example stated "The lesson study experience has helped me to improve my lesson planning, but more importantly it helps me to objectively see where I could be better, and how."

Table 6 identifies the alphanumeric code of each resident teacher who stated that lesson study helped his or her growth as a teacher. It also contains every quote that addresses lesson study helping their growth as a teacher from each of their reflections. Specific areas the teachers identify growing in as a result of participating in lesson study include lesson planning and instructional strategies.

Table 6

*Resident Teacher Reflection Theme: Belief Lesson Study Helped Growth as a Teacher (*N = *9)*

Resident Teacher	Quotes Related to Theme
Female Biology A.1.1	I believe my tools of instruction strategies in AP Biology were heightened through this experience.
Female Biology A.1.3	Even though there were a couple of flaws in the planning process, I really feel like this lesson study has been the most helpful to my development as a teacher.
Male Biology A.1.1	The lesson study experience has helped me to improve my lesson planning, but more importantly it helps me to objectively see where I could be better, and how.
Male Physics A.1.1	After the lesson study I have made attempts to put more thought into the way in which I'm having my students learn a new topic and I've tried to design more ways for my students to demonstrate their learning throughout a unit.
	It was very helpful for me to see how other teachers prepare and present lessons and because of that I was able to better learn how to do it better myself in the future.
Female Biology B.1.1	The best part of this modified lesson study was the opportunity to watch others teach lessons and use strategies that I have not yet thought of or been exposed to.
Male Life Science B.1.1	It was reward to work with a group of peers who are consistently striving to become better professionals and I was able to learn and see new techniques and strategies that can be utilized in my classroom.
Female Chemistry B.2.1	I have collaborated immensely with my other cohorts and have gained invaluable information from them whether it is based on the procedures in the classroom, the teaching strategies they use, or if they explained a similar concept in my subject area one way versus another."
Female Mathematics B.2.1	Also, planning the lesson collaboratively helped give me ideas for my own lessons in the future and different methods and strategies for creating a lesson plan and types of activities I could include in the lesson to engage the students.
Geometry Team E.2.1	I was able to get a glimpse of the thought process that more experienced teachers use to plan lessons. Being a relatively new teacher, this is one area that I struggle in greatly.
	Moreover, I learned about other instructor techniques, finding new ways of teach the same concepts.

Additional Findings

Careful analysis of the resident teachers' lesson study reflections and teacher work sample reflections reveals several additional findings. Throughout the 37 reflections analyzed, 10 themes were noted. Table 7 contains a list of themes contained in the resident teacher reflections. A theme was identified as any common experience or statement made by two or more resident teachers. Of the 10 themes that were noted, 5 themes emerged as the most frequently noted. Each of these occurred in nine or more resident teacher reflections. The most frequently occurring themes were: the belief that lesson study helped the resident teacher grow as a teacher (as outlined in the discussion of findings related to Research Question 3 above); a desire to participate on future lesson study research teams; an increased focus on student learning; an overall positive experience; and the value found in collaboration.

Table 7

*Themes from Resident Teacher Reflections (*N = *37)*

Theme (*n*) [a]	Subtheme (*n*) [b]	Resident Teacher Alphanumeric Code
Positive Experience (*26)*	Desire to Participate in Future on Future Lesson Study Teams (*11*)	Female Biology A.1.2 Female Biology A.1.4 Female Biology A.1.5 Female Middle School Science A.1.1 Male Physics A.1.1 Female AP/Gifted Biology B.1.1 Female Physics B.1.1 Female Algebra 1 E.1.1 Male Biology E.1.2 Female Mathematics B.2.3 Physics Team E.2.1
	Belief Lesson Study Should be Required PD (*2*)	Female Biology A.1.1 Male Biology E.1.2
	General/Other (*14*)	Male Biology A.1.1 Female Biology B.1.1 Male Biology E.1.1 Male Physics A.2.1 Male Life Science B.1.1 Female Chemistry B.2.1 Male Chemistry B.2.1 Female Mathematics B.1.1 Female Mathematics B.2.1 Female Mathematics B.2.2 Algebra 2 Team E.2.1 Biology Team E.2.1 Chemistry Team E.2.1 Geometry Team E.2.1
Collaboration (*22*)	With Teachers of Same Content Area (*4*)	Female Biology A.1.1 Female AP/Gifted Biology B.1.1 Male Physics A.2.1 Female Mathematics B.2.4
	With Teachers from Other Schools (*3*)	Female Biology A.1.3 Male Biology A.1.1 Female AP/Gifted Biology B.1.1
	With Mentor (*2*)	Female Biology A.1.2 Female Biology A.1.3

Theme (*n*) [a]	Subtheme (*n*)[b]	Resident Teacher Alphanumeric Code
	General/Other (*15*)	Female Biology A.1.4 Female Biology A.1.5 Male Physics A.1.1 Female Biology B.1.1 Male Life Science B.1.1 Female Mathematics B.1.1 Male Biology E.1.1 Female Chemistry B.2.1 Male Chemistry B.2.1 Female Mathematics B.2.1 Algebra 2 Team E.2.1 Biology Team E.2.1 Chemistry Team E.2.1 Geometry Team E.2.1 Physics Team E.2.1
Focus on Students (*10*)	None	Female Biology A.1.1 Female Biology A.1.4 Female Middle School Science A.1.1 Male Physics A.1.1 Male Life Science B.1.1 Female Mathematics B.1.1 Female Mathematics B.2.1 Female Mathematics B.2.2 Algebra 2 Team E.2.1 Geometry Team E.2.1
Concern about Time Required (*2*)	None	Female Biology A.1.5 Geometry Team E.2.1

[a] Number of unique individuals with responses categorized under a given theme. [b] Respondents may be identified under multiple subcategories, as appropriate; to wit, subtheme response totals may exceed 100% of responses for a given theme.

Desire to Participate on Future Lesson Study Research Teams

Table 8 contains data outlining which resident teachers indicated they held a desire to participate on future lesson study research teams. Eleven of the 37 reflections (30%) that mentioned lesson study contained verbiage indicating the resident teachers looked forward to participating on future lesson study teams, citing the numerous benefits outlined in previous sections. Some resident teachers even went beyond a desire of their own to participate in future

lesson study sessions, with one female biology teacher believing the benefits to be so great that lesson study should be required professional learning each year, and adding that her tools of instruction had been heightened by the experience (Female Biology A.1.3). Another female biology teacher indicated a strong appreciation for the opportunity to collaborate with teachers from outside her school, adding that she hoped "to one day establish a collective of teachers from different schools to meet and share lessons based on this experience" (Female AP/Gifted Biology B.1.1).

Table 8

Resident Teacher Reflection Theme: Desire to Participate on Future Lesson Study Teams

*(*N = *11)*

Resident Teacher	Quotes Related to Theme
Female Biology A.1.2	What I hope to take from this experience is more opportunities to collaborate with my mentors, and an improved habit of reflecting on the results of my lessons.
Female Biology A.1.4	After participating in a lesson study cycle, I am excited to continue using lesson study for professional development.
	I would like to build on this lesson study and complete more science centered studies
Female Biology A.1.5	Overall, I really enjoyed this lesson study and hope to be able to participate in more.
Female Middle School Science A.1.1	I think that I would like to incorporate this activity more often.
Male Physics A.1.1	I really enjoyed the opportunity and would be very open to it again in the future.
Female AP/Gifted Biology B.1.1	In fact, I hope to one day establish a collective of teachers from various schools who meet to share lessons and effective activities that we can bring back to our own schools.
Female Physics B.1.1	Overall, my experience in the lesson study was positive and I would definitely be open to doing this again.
Female Mathematics B.2.3	I think more teachers should participate in lesson studies; however I don't know the best process to incorporate them.
Female Algebra 1 E.1.1	I look forward to the next lesson study to improve not only my teaching practices, but to explore and improve online teaching practices in general.
Male Biology E.1.2	Honestly I would definitely teach this lesson again and work with the same group for any other lesson studies.
	Lesson studies are very important and I think these sessions should happen all throughout the year
Physics Team E.2.1	I look forward to altering the other Live Lessons with what we learned in this cycle.

An Increased Focus on Student Learning

Another trend noticed in the reflections analyzed was how beneficial participating in lessons created through lesson study was for the students. Table 9 indicates that of the 37 analyzed resident teacher reflections, 10 (27%) either stated that lesson study posed a benefit for students or described observed benefits to students, and several even provided specific data demonstrating learning gains by students who participated in lessons planned by lesson study teams. One female Algebra 2 teacher indicated that lesson study helped her team to "focus anew on student achievement in a way that provided real data on effective, increased learning" (Algebra 2 Team E.2.1). Several others wrote that students demonstrated an improved understanding of the topic in post lesson assessments, with a female biology teacher even reporting that students went from scoring 50% on the pre-test to scoring 100% correct on the post-test based on the lesson study lesson. Increased student engagement was also reported, though this could have been a side effect of having multiple adults comprising the lesson study team in the room while a lesson was being taught.

Table 9

*Resident Teacher Reflection Theme: An Increased Focus on Student Learning (*N = *10)*

Resident Teacher	Quotes Related to Theme
Female Biology A.1.1	This was an ah-ha moment for me because I never really sit down and think about what I should see the students doing and hear them saying as a lesson continues.
Female Biology A.1.4	It gave me as a new perspective on how students react to given wait times and collaborate in groups.
Female Middle School Science A.1.1	I feel like this activity told me a lot of information about where my students were.
Male Physics A.1.1	What seemed like simple questions such as how do you handle misconceptions that students have early on turned into a large debate over whether you should let students continue to have that misconception and learn that it is false as the lesson carries on or if it is more beneficial to students to see that it is a misconception immediately.
	After the lesson study I have made attempts to put more thought into the way in which I'm having my students learn a new topic and I've tried to design more ways for my students to demonstrate their learning throughout a unit.
Male Life Science B.1.1	I feel that the lesson study model promotes educators to collaborate and create lesson plans that are highly effective in impacting student engagement and learning.
Female Mathematics B.1.1	Listening to the student responses provided a lot of insight in terms of improving the lesson.
	As I observed student questions such as "where does the tape go?" it became evident that developing an effective lesson is a collaborative effort that requires input from different viewpoints.
	After participating in this lesson study I can effectively visualize what lesson study is and how it can be used to impact student learning.
Female Mathematics B.2.1	This lesson study was a good reminder that the focus of a lesson is on student learning and the needs of the students.
Female Mathematics B.2.2	Overall, it was very helpful to see my own students react to the lesson.
	I was able to gather information on their learning, and on their engagement.
	The shift in the lesson increased student engagement.
Algebra 2 Team E.2.1	By actively engaging students and including them in the learning process helps guarantee their success with the material.
	Lesson Study helped us focus anew on student achievement in a way that provided real data on effective, increased learning.
Geometry Team E.2.1	It became apparent to me that students learn much more efficiently when they are given the opportunity to interact with the content in many different ways.
	Student learning takes place based on student engagement and I feel that this lesson actively engaged the students.

A Positive Experience

The 37 written resident teacher reflections analyzed overwhelmingly indicate that lesson study was found to be a positive experience. Table 10 states that out of the 37 resident teacher reflections analyzed, 26 reflections (70%) contain statements indicating that lesson study was beneficial. Examples of statements of those who found the lesson study experience to be beneficial include one from a female mathematics teacher who wrote that lesson study helped her to recognize the benefit of collaboration, gain insight, and realize the value of reflection (Female Mathematics B.1.1). Another female biology teacher wrote that although there were flaws in the process, lesson study was "the most helpful to my development as a teacher" (Female Biology A.1.2).

Table 10

*Resident Teacher Reflection Theme: A Positive Experience (*N = *26)*

Resident Teacher	Quotes Related to Theme
Female Biology A.1.1	I think we should have to complete a lesson study at least twice a year for professional development.[a]
	I loved it.
Female Biology A.1.2	Overall, I really enjoyed collaborating with my colleagues and mentors during lesson study.
Female Biology A.1.4	I enjoyed participating in the creation of this lesson.
Female Biology A.1.5	I found this lesson study experience very interesting.
	I enjoyed listening to my colleagues' ideas and suggestions on how to teach this lesson.
Male Biology A.1.1	I am grateful for the opportunity to see how other teachers use their resources.
Female Middle School Science A.1.1	I think that I would like to incorporate this activity more often.
Male Physics A.1.1	Having the opportunity to see how more experienced teachers approach a topic like student understanding was invaluable to see how their thought processes at work.
Female Biology B.1.1	As a novice teacher, I appreciated watching veteran teachers demonstrate a lesson.
	I also enjoyed watching the other teachers' classroom management styles.
	Overall, I enjoyed this modified lesson study.
Female AP/Gifted Biology B.1.1	I greatly enjoyed being able to collaborate with a teacher outside my school.
	I think this type of cross-school collaborative compare-and-share was one of the most valuable experiences that the RTP^3 program has provided.
Male Life Science B.1.1	Overall, I thoroughly enjoyed the lesson study process.
	I feel that the lesson study model promotes educators to collaborate and create lesson plans that are highly effective in impacting student engagement and learning.
Female Mathematics B.1.1	Participating in the lesson study was very insightful for me.
	In conclusion, I learned so much from this lesson study.
Female Physics B.1.1	Overall, my experience in the lesson study was positive and I would definitely be open to doing this again.
Female Algebra 1 E.1.1	I look forward to the next lesson study to improve not only my teaching practices, but to explore and improve online teaching practices in general.
Male Biology E.1.1	I really enjoyed participating in the lesson study this semester.
Male Biology E.1.2	Lesson studies are very important and I think these sessions should happen all throughout the year.[a]

Resident Teacher	Quotes Related to Theme
Male Physics A.2.1	Working together in a PLC like this made me very happy, as I was able to have someone to help me come up with new ideas, but also allowed me to have someone who knows the subject matter to bounce my ideas off of.
Female Chemistry B.2.1	I have collaborated immensely with my other cohorts and have gained invaluable information from them whether it is based on the procedures in the classroom, the teaching strategies they use, or if they explained a similar concept in my subject area one way versus another.
Male Chemistry B.2.1	While technology is becoming more and more pervasive in the 21st century classroom, there are still old school techniques that are unbeatable, like collaboration with other teachers.
Female Mathematics B.2.1	It was nice to see it from the perspectives of other teachers, especially as a new teacher, and see their ways and ideas of approaching teaching the lesson.
	Thus, I think, even though lesson studies are time consuming, they are very useful and beneficial, and I will continue to think and reflect upon my lessons in the future as I did within this lesson study.
Female Mathematics B.2.2	Overall, it was very helpful to see my own students react to the lesson.
	I was able to observe so much more than I normally do while I'm teaching.
Female Mathematics B.2.3	I think more teachers should participate in lesson studies; however I don't know the best process to incorporate them.
Algebra 2 Team E.2.1	I gained new insight into the value of posing thought-provoking questions to students.
	This was the first chance I have had at (School District E) to really pick apart a lesson and that was very beneficial.
	Lesson Study helped us focus anew on student achievement in a way that provided real data on effective, increased learning.
Biology Team E.2.1	Furthermore, it seems to be a beneficial practice to have a skilled observer present during a session to collect data on a lesson, given that some student behavior can be overlooked easily when a teacher is immersed in instruction.
Chemistry Team E.2.1	We were very successful in working as a team to create and present a live lesson that allowed for the collection student data.
Geometry Team E.2.1	I was able to get a glimpse of the thought process that more experienced teachers use to plan lessons. Being a relatively new teacher, this is one area that I struggle in greatly.
	Moreover, I learned about other instructor techniques, finding new ways of teach the same concepts.
Physics Team E.2.1	Student learning takes place based on student engagement and I feel that this lesson actively engaged the students.
	It was eye opening to go through the process of the lesson study.
	I look forward to altering the other Live Lessons with what we learned in this cycle.

[a] Subtheme: Belief Lesson Study Should be Required Professional Development (n = 2)

Value in Collaboration

Another benefit of lesson study frequently reported by resident teachers in their reflections was the value found in collaboration. As shown in Table 11, 22 of the 37 reflections that mention lesson study (59%) stated that it was beneficial to work together with other teachers. Reflections often portrayed resident teachers being in awe of the veterans. They expressed that they felt fortunate to work with veterans, with one resident teacher stating that "having the opportunity to see how more experienced teachers approach a topic like student understanding was invaluable" (Male Physics A.1.1). Some specified they valued collaborating with specific people, including three resident teachers who specified that they enjoyed collaborating with teachers from other schools, four resident teachers who appreciated collaborating with teachers from their same content area, and two resident teachers who pointed out the value of having mentors participate in the collaboration. Resident teachers valued several aspects of collaboration, with some enjoying observing how other teachers prepare and present lessons, some appreciating the variety of resources provided by teachers, and many resident teachers valuing the chance to see veterans in action. From these veteran teachers they gleaned knowledge about teaching styles and strategies, classroom management, and how to develop "lesson plans that are highly effective in impacting student learning and engagement" (Male Life Science B.1.1).

Table 11

*Resident Teacher Reflection Theme: Value of Collaboration (*N *= 22)*

Resident Teacher	Quotes Related to Theme
Female Biology A.1.1	Therefore it was a great experience to have the opportunity to discuss lesson ideas with other teachers in the same discipline.
Female Biology A.1.2	It was interesting to see what my colleagues noticed, and what I may have missed.
	Overall, I really enjoyed collaborating with my colleagues and mentors during lesson study.
	I have recognized the cumulative benefit of collaboration, and just how much insight can be gleaned from additional input.
	What I hope to take from this experience is more opportunities to collaborate with my mentors, and an improved habit of reflecting on the results of my lessons.
Female Biology A.1.3	And the best part of all was getting to collaborate with not only teachers from my school, but my mentor who teaches at another school and the lesson study facilitators.
Female Biology A.1.4	Planning a lesson together was fun, and I thought that being able to bounce ideas about activities and questions for the students was helpful in planning a successful and cohesive lesson.
Female Biology A.1.5	I enjoyed listening to my colleagues' ideas and suggestions on how to teach this lesson.
	It was refreshing to have not only one new point of view to consider, but many, since everyone in the lesson study participated in putting forth our ideas.
Male Biology A.1.1	At my school I am the only science teacher, so this was a wonderful opportunity for me to collaborate with other science teachers, share notes, and see how they utilize their resources and present the information to the students.
	I am grateful for the opportunity to see how other teachers use their resources.
	Even though I don't have all the same resources available at my school, there are many things I hadn't thought of that I can easily purchase or bring in to the school.
Male Physics A.1.1	Having the opportunity to see how more experienced teachers approach a topic like student understanding was invaluable to see how their thought processes at work.
	As a teacher that began without a background in education the lesson study also served as an exciting opportunity to watch an experienced teacher in their own element of planning, teaching and critiquing their own lesson, something I haven't had much opportunity to see.
	It was very helpful for me to see how other teachers prepare and present lessons and because of that I was able to better learn how to do it better myself in the future.
Female Biology B.1.1	As a novice teacher, I appreciated watching veteran teachers demonstrate a lesson.
	I also enjoyed watching the other teachers' classroom management styles.
	The best part of this modified lesson study was the opportunity to watch others teach lessons and use strategies that I have not yet thought of or been exposed to.

Resident Teacher	Quotes Related to Theme
Female AP/Gifted Biology B.1.1	I was able to collaborate with another (School District B) Biology Honors teacher in the RTP3 program.
	I greatly enjoyed being able to collaborate with a teacher outside my school.
	Although I have an extremely cooperative PLC among the biology teachers at my school, it was a welcome change to expand our collective idea bank by working with someone coming from a different school who has a different set of resources from her own planning and from the other teachers in her PLC.
	I think this type of cross-school collaborative compare-and-share was one of the most valuable experiences that the RTP3 program has provided.
	In fact, I hope to one day establish a collective of teachers from various schools who meet to share lessons and effective activities that we can bring back to our own schools.
Male Life Science B.1.1	It was very interesting to watch how the other teacher completed the scripted lesson and how the students responded to the lesson.
	I feel that the lesson study model promotes educators to collaborate and create lesson plans that are highly effective in impacting student engagement and learning.
	It was reward to work with a group of peers who are consistently striving to become better professionals and I was able to learn and see new techniques and strategies that can be utilized in my classroom.
Female Mathematics B.1.1	Working with fellow colleagues exposed me to different point of views and different approaches to implementing a lesson.
	This made me realize that it is a privilege to work with colleagues because they can bring different ideas and ways of thinking to the table.
	It was good to hear the other member's responses because they introduced phrases that I had overlooked or never thought of. Once again this made me realize the importance of collaborating.
Male Biology E.1.1	All in all the lesson study was a success and it was extremely helpful collaborating with all the teachers.
Male Physics A.2.1	Working together in a PLC like this made me very happy, as I was able to have someone to help me come up with new ideas, but also allowed me to have someone who knows the subject matter to bounce my ideas off of.
Female Chemistry B.2.1	I have collaborated immensely with my other cohorts and have gained invaluable information from them whether it is based on the procedures in the classroom, the teaching strategies they use, or if they explained a similar concept in my subject area one way versus another.
Male Chemistry B.2.1	While technology is becoming more and more pervasive in the 21st century classroom, there are still old school techniques that are unbeatable, like collaboration with other teachers.
	The unit lesson plan was designed with tremendous insight from other teachers within the department.

Resident Teacher	Quotes Related to Theme
	The department has, on average, 15 years or more experience, and I can greatly benefit from their advice for how to bridge content with memorable demonstrations and lab activities.
Female Mathematics B.2.1	Also, planning the lesson collaboratively helped give me ideas for my own lessons in the future and different methods and strategies for creating a lesson plan and types of activities I could include in the lesson to engage the students.
	It was nice to see it from the perspectives of other teachers, especially as a new teacher, and see their ways and ideas of approaching teaching the lesson.
Female Mathematics B.2.4	I have talked with the other members on my professional learning committee about what data would could pull from giving a pre and post assessment; and they agree to make pre assessments fit into our instructional plans during next year.
Algebra 2 Team E.2.1	The collaboration went smoothly.
	I gained new insight into the value of posing thought-provoking questions to students.
Biology Team E.2.1	The team collaborated very well. Everyone was respectful and a team-player. There was a very equal share in workload and response.
	Furthermore, it seems to be a beneficial practice to have a skilled observer present during a session to collect data on a lesson, given that some student behavior can be overlooked easily when a teacher is immersed in instruction.
Chemistry Team E.2.1	We were very successful in working as a team to create and present a live lesson that allowed for the collection student data.
	There are many different types of people on the team (data-driven, creative, funny, serious, etc.), which makes it well-rounded.
Geometry Team E.2.1	The individuals who worked on this lesson study did an outstanding job working together as a team.
	Each member contributed throughout the entire cycle and provided valuable insights on the development of the lesson.
	I was able to get a glimpse of the thought process that more experienced teachers use to plan lessons. Being a relatively new teacher, this is one area that I struggle in greatly.
	I gained insight on the data that can be collected from a session and the validity of a session.
	Moreover, I learned about other instructor techniques, finding new ways of teach the same concepts.
Physics Team E.2.1	The team I am on is amazing. The depth of experience that Norma and Michelle have is frankly astounding. It was certainly a great help to work with them through this experience.
	We worked together with the common goal of making sure that students learn momentum and to present the best possible lesson.

Summary

The chapter began with an introduction containing a reminder of the problem that inspired this study along with the purpose of the study. The findings of the research questions were presented, beginning with research question one regarding the lesson study models used by each school district. These findings indicated that School District A followed the lesson study model developed by RTP^3 and emphasized the use of a Knowledgeable Other in the form of a university professor. School District B started out using the RTP^3 lesson study model but experienced frustration throughout the process and found it difficult to consistently get schools to participate in lesson study. School District E used a different lesson study model which involved primarily virtual collaboration.

Findings related to research question two were then presented. These findings demonstrated that School District A did not change their lesson study model after participating in RTP^3. They did, however, examine their previously held beliefs, specifically with regard to incorporating the Knowledgeable Other and completing lesson study in one day rather than in two half-day sessions. School District B did not change their model based on the experience of participating in RTP^3 lesson study and the school district designee is unsure if they are even still implementing lesson study anywhere in the school district. As a result of their participation in lesson study through RTP^3, School District E has expanded lesson study throughout the school district.

The findings for research question three were then presented, highlighting that 24% of resident teacher reflections indicated that participation in lesson study had helped their growth as a teacher. This growth was usually stated as either an overall claim of improvement as a teacher

due to participation lesson study or the identification of specific skills related to teaching that improved thanks to participation in lesson study. Lastly, additional findings were presented in the form of a table showing the themes identified in the resident teacher lesson study reflections. The most frequently noted themes were also presented. Those themes were: the belief lesson study helped growth as a teacher; the desire to participate in future lesson study research teams; an increased focus on student learning; a positive experience; and value in collaboration. The next chapter will contain a discussion of the findings, implications for practice, and recommendations for future research.

CHAPTER 5
SUMMARY, DISCUSSION, AND CONCLUSIONS

Introduction

In the previous chapter, data related to the research questions was presented and analyzed. Chapter 5 contains a summary of the study followed by a discussion of the findings. Implications for practice for teacher preparation programs, teachers, and school administrators are examined, followed by various recommendations for research including both additional topics related to the study that should be research and ways this study could be improved upon. The chapter will end with final concluding thoughts.

Summary of the Study

The problem to be researched was that STEM graduates who entered into education need a model of collaborative reflective practice for continuous improvement. Lesson study was included in the RTP^3 proposal and was funded as it is a model of professional learning that is both collaborative and reflective, and the cyclical nature of lesson study makes it a natural fit for continuous improvement. However, little research into the effectiveness of lesson study as a tool for teacher preparation exists. The purpose of the study was to determine the extent to which participating in lesson study was perceived to have an impact on teacher effectiveness.

Three research questions were used to guide the study. The first two questions related to lesson study models used by each of the three sampled school districts: "What is the lesson study model of each of the three sampled RTP^3 partner school districts?" and "To what extent did partner school districts modify lesson study implementation as a result of participating in RTP^3?" The third research question focused on RTP^3 resident teachers' observations of the

benefits of lesson study: "To what extent do the sampled RTP^3 resident teachers perceive that lesson study assisted them in improving teacher effectiveness?"

Regarding the methodology of the study, the research design used qualitative data collected through interviews and a post hoc analysis of artifacts, primarily resident teacher reflections on lesson study. Interviews were held with designees from each of the three sampled school districts regarding both sections of research question 1. The sample was drawn from Cohorts 1 and 2—all available reflections from School Districts A, B, and E were analyzed. Only three of the five RTP^3 partner school districts were used for sampling as the other two school districts represented only 13 resident teachers in both cohorts. The artifacts analyzed include the RTP^3 lesson study model and reflections from the resident teachers. Reflections were completed as part of the RTP^3 job embedded two semester internship.

The population of this study included all of the 103 resident teachers from each of the five RTP^3 partner school districts. However, the sample was limited to the 37 teachers in Cohorts One and Two of the RTP^3 from School District A, School District B, and School District E whose resident teacher reflections were available. The resident teachers were only identified by what content area they taught (mathematics or science) and their gender. The specific questions used when interviewing the school district designees can be found in Appendix A. The artifacts, resident teachers' reflections, and interviews were analyzed using the constant comparison method (Parry, 2004). The reflections were closely examined for trends and patterns, and as commonalities emerged, they led to the findings of this study. After review of the sampled RTP^3 partner school district lesson study models, they were confirmed and explored during the interviews with school district designees.

Discussion of the Findings

Previous studies confirmed that participating in lesson study is beneficial for teachers (Lewis et al, 2011; Robinson & Leiken, 2011; Sims & Walsh, 2009). The goal of this study was to determine the extent to which participating in lesson study was perceived to have an impact on teacher effectiveness. This section examines the findings for each of the research questions.

Research Question One

What is the lesson study model of each of the three sampled RTP^3 partner school districts?

Research Question Two.

To what extent did the sampled RTP^3 partner school districts modify lesson study implementation as a result of participating in RTP^3?

The findings resulting from research questions one and two show that adherence to the chosen lesson study model impacted future participation in lesson study. Each of the lesson study models were outlined in Chapter 4. If time and resources were not allotted to make lesson study a priority, the school district was less likely to continue participating in lesson study once RTP^3 ended. School Districts A and E adhered to their chosen lesson study model with fidelity. Their designees indicated that they faithfully participated in lesson study and, consequently, they looked forward to continuing to explore the use of lesson study beyond their participation in RTP^3. School District B, on the other hand, found it more difficult to consistently participate in lesson study, causing them to do whatever it took to get RTP^3 participants through the program. The designee from School District B also indicated that she was unsure if lesson study was still in use anywhere in the school district as of October 2014. While adherence to the chosen lesson study model impacted the likelihood of future participation in lesson study, it did not impact the perceived value of lesson study, as resident teachers from School District B reflected positively

on their experiences with lesson study. The data indicate that participating in lesson study had the most impact on School District E. They responded to the experience of participating in lesson study through RTP^3 by incorporating lesson study districtwide.

Research Question Three

To what extent do RTP^3 resident teachers perceive that lesson study assisted them in improving teacher effectiveness?

The findings for research question three indicate that the sampled RTP^3 resident teachers perceived lesson study to be beneficial to their growth as educators in a variety of ways, confirming the research of Lewis et al (2011), Robinson & Leiken (2011), and Sims & Walsh (2009). The most frequently documented experiences of the resident teachers were the belief lesson study helped growth as a teacher; the desire to participate on future lesson study research teams; an increased focus on student learning; a positive experience overall; and the value found in collaboration.

Resident teachers were inspired by lesson study to focus on student growth and learning, confirming the findings of Ylonen and Norwich (2012). Resident teacher reflections also confirmed the work of Cohn and Honigsfeld (2007), noting that student performance data improved after participating in lesson study. The research of Simmons (2005) was also affirmed as the RTP^3 resident teachers indicated they benefitted from collaborating with veteran educators in both the form of experienced teachers, RTP^3 mentors, and knowledgeable others such as university professors. Also noteworthy was the finding that lesson study did not need to be conducted face to face for the resident teachers to perceive these benefits. RTP^3 resident teachers from School District E participated in lesson study virtually, collaborating online, and reported the same benefits as the other two school districts.

These conclusions are further supported by the survey data reviewed in the RTP[3] End of Project Final Summative Evaluation Report. The survey data shared in that report indicate that resident teachers felt lesson study helped them in a variety of ways, including: building their professional community; thinking more carefully about goals for teaching particular lessons, units, or subject areas; deepening their knowledge about students and student thinking; and building their knowledge base for teaching (Swan et al., 2014, p. 64). This data highlights the myriad benefits to teachers who participate in lesson study.

Implications for Practice

Upon examining the data and findings of this study, several implications for practice are readily apparent. These will be outlined in sections related to three separate audiences: teacher preparation programs, teachers, and administrators.

Implications for Teacher Preparation Programs

Teacher preparation programs should examine their internships to consider how they might incorporate participation in lesson study (assuming it is not already a part). The data demonstrate that resident teachers benefited from the shift in perception of examining their teaching to considering what students were learning. Similarly, collaborating with veteran teachers was beneficial as it exposed them to strategies and methods of teaching they may not have previously observed. Therefore, if possible, teachers with a variety of experiences should be part of this lesson study team.

Implications for Teachers

While teachers may not be able to decide on their own that they would like to participate in lesson study at their schools, the benefits of collaboration were strong enough that they should consider ways they might collaborate with others. The data revealed that even when resident teachers collaborated with those who did not teach the same subject or who were not teaching at the same physical location, they benefited from the collaboration. Even collaborating virtually was beneficial. This leaves plenty of options for teachers to explore if they would like to reap the benefits of collaborating with others. Possible ways teachers could collaborate include working together with teachers in their school to plan lessons or develop common assessments. Based upon the experience of School District A, it might be beneficial for the teachers to seek out purposeful and deliberate partnerships with a local university in order to incorporate a university professor as a knowledgeable other.

Implications for Administrators

Administrators should examine their budget and the professional learning they have planned and determine if they can find a way to incorporate lesson study with fidelity. It can be challenging with the amount of time required for quality lesson study. But the data clearly show the benefits to teachers and students are massive. The benefits of collaboration support the current trend toward professional learning communities. It is essential for administrators to understand the commitments required for lesson study along with the importance of fidelity to the lesson study model. School District B did not stick to the established model, and experienced noticeably worse results than School District A and School District E. Administrators should also consider whether it would be possible to bring in a knowledgeable other from a local

university to participate in the lesson study cycles. Similarly, school district leaders should consider whether it would be possible to incorporate lesson study districtwide, keeping in mind the need to implement lesson study with fidelity to the established model to ensure the highest chance of teachers and students reaping the benefits. School district leaders and school administrators should also be cognizant of the rigor found in lesson study. Deep thinking is required of lesson study participants and the lesson study facilitator. This rigor can create a barrier to effective lesson study if it is not addressed.

Recommendations for Further Research

Recommendations for further research based upon this study fall in two categories: limitations and suggestions for replication studies and researchable topics related to this study.

Limitations and Suggestions for Replication Studies

The study succeeded in its goal of determining that participating in lesson study was perceived to have an impact on teacher effectiveness. However, the limitations placed on the study impact the generalizations that can be made based upon the data and findings. Should the study be replicated, the following suggestions would improve generalizability:

1. Gather data from school districts around the nation rather than only in Florida. This would make the study generalizable to the rest of the United States.
2. Gather data from teachers across all grade levels and content areas rather than only from STEM teachers in middle and high schools. This would make the study generalizable to other content areas and grade levels.

3. Gather data from teachers who are undergraduate college of education students rather than only from Master of Arts in Teaching students. This would make the study generalizable to undergraduate college of education students.
4. Gather assessment data from the teachers who participate in lesson study in order to study effects of participation rather than perceived value of lesson study.
5. Require participating school districts to follow the lesson study model with fidelity. The results from School District B may not be as reliable as those from School Districts A and E, as they did not follow the lesson study model with fidelity.
6. Provide specific questions to guide reflections. A survey could even be used to generate more quantitative data and have hard numbers regarding specific questions such as "was lesson study valuable?" or "did you benefit from collaborating with veteran teachers?"

Researchable Topics Related to the Study.

Several topics related to this study revealed themselves through the reflection data and interviews. Variances in how teachers participate in lesson study could be examined in several ways. Comparing and contrasting the experiences and perceived benefits of teachers who participate in traditional face-to-face lesson study cycles with the experiences and perceived benefits of teachers who participate in virtual lesson study cycles online could lead to interesting results. Slight variations of this would be to explore cross-curricular lesson study teams or cross-school lesson study teams. Use of existing and emerging technologies as a method to participate in lesson study could also be researched. Another option would be to examine incorporating the knowledgeable other—a researcher could use control groups of traditional lesson study teams

and use the knowledgeable other as a variable. One of the most valuable options would be to study assessment data related to lesson study—comparing the data of teachers who participated in lesson study with the data of teachers who did not. There is a great need for this sort of data related to lesson study, as previously pointed out in the gaps in the literature in the literature review section.

Conclusions

The data presented in this study are clear: benefits were perceived by resident teachers from each of the three sampled RTP^3 partner school districts, including an increased focus on students and student learning along with the benefit of learning new strategies through collaborating with other teachers. Teacher preparation programs should closely examine their internships to consider how they might incorporate lesson study into them. Administrators should find the time and resources to incorporate this collaborative process on their campus. Further research into aspects of lesson study such as contrasting the results of face to face lesson study with the results of virtual lesson study, along with research into the knowledgeable other, could shed more light on this powerful tool and the best way to use it to prepare and develop teachers.

APPENDIX A:
PARTNER SCHOOL DISTRICT INTERVIEW QUESTIONS

1. Please tell me about your school district's interest in participating in RTP^3.
2. Please describe your school district's RTP^3 lesson study model, addressing how lesson study was conducted and who made up the lesson study research teams.
3. How does this model and participation compare to the level of participation in lesson study (district-wide)?
4. How did you track participation in and results of lesson study experience for mentors and resident teachers?
5. To what extent did your school district modify lesson study implementation in general as a result of participation in RTP^3?

APPENDIX B:
INFORMED CONSENT LETTER

Dear RTP^3 Partner,

Thank you for taking the time to participate in this study about your school district's commitment to investing in teachers and your impassioned drive toward improving student achievement through a highly structured and supported mentoring program for STEM students in the Resident Teacher Professional Preparation Program (RTP^3). Lesson Study is a component of a Race to the Top grant, RTP^3. The purpose of the study is to determine the extent to which participation in a lesson study research team has an impact on teacher effectiveness.

Your participation in this study is entirely voluntary. Whether or not you take part, is up to you. You may select to change your mind while in the process of participating in this study. There is no consequence for your acceptance or rejection to participate in the study.

The interview is confidential and your identity will be known only to the researcher. The interview will be recorded but only for the purpose of ensuring that the researcher is accurate in reporting the information resulting from the interviews. No personally identifiable data will be reported. Other than clarifications to the lesson study model, data will be reported in aggregate. The interview is expected to last about 20 minutes.

If you have any questions in regards to this study please do not hesitate to contact me at danthompson@knights.ucf.edu. My faculty advisor, Dr. Rosemarye Taylor, may be contacted by phone at (407) 823-1469 or by email at rosemarye.taylor@mail.ucf.edu. Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (IRB). Questions or concerns about research participants' rights may be directed to the UCF Institutional Review Board Office at the University of Central Florida, Office of Research and Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246. The phone numbers are (407) 823-2901 or (407) 882-2276.

Best Regards,
Daniel Thompson
Doctoral Candidate, University of Central Florida

APPENDIX C:
NOTES FROM PARTNER SCHOOL DISTRICT DESIGNEE INTERVIEWS

Interview with RTP^3 Partner School District A Designee, Conducted at 7:45 pm on Wednesday, August 20th 2014

1. Please tell me about your school district's interest in participating in RTP^3.

RTP^3 Partner School District A Designee: Mandy Ellis was approached by UCF to collaborate together in writing this grant, so she was in from kind of the ground up in putting this together for our STEM teachers that did not go through education programs and thinking about how we can best support them when they are coming (to us) without the coursework and internships that come with education programs. This helped us a lot with this group who are non-education majors.

2. Please describe your school district's RTP^3 lesson study model, addressing how lesson study was conducted and who made up the lesson study research teams.

RTP^3 Partner School District A Designee: Our lesson study model consisted of all of the requirements that we talked about through RTP^3, and I don't have them all written in front of me but based on teams collaborating, planning together, collecting data on students, analyzing the data and reflecting on it, as well as using a knowledgeable other. We had a couple models for our teams; typically we would put a beginning teacher in the program working with their PLC with the addition of their mentor, in some cases all in one. Like at Oak Ridge for example, we had a teachers team with the addition of the mentor teacher and the addition of their expertise. We also had some teams where we had the PLC and the teacher with a mentor from a different school; they would come join the cycle to support the beginning teacher. We also had teams of like-content people, for example our physics team. There is rarely more than one (physics teacher) at a school so we had beginning teachers from the program who taught physics, their mentors, and then a physics teacher from cohort one. They did two cycles, so for the

second cycle we still had one of the mentors on the team so we were reaching all sides there. The team consisted of people from different schools but they taught a common content.

When mentors came from different schools they were able to bring their expertise or resources that the other schools may not have had. On one of our marine science teams the two veteran teachers we worked with hadn't taught marine science before, so the course was new for everyone. The mentor teacher was able to help the entire team even the veteran teachers, not just the new teacher. She also brought resources such as sponges when the teachers didn't have any. So she brought resources they needed to teach the content. The knowledgeable other, Dr. Erhan Selcuk Haciomeroglu, was another unexpected benefit. One of the teams was looking at problems that you selected for kids based on your intent for learning. With very few questions he was able to help them with choosing problems that hit more than one math concept. The other team he helped understand a foundational concept of angles that they really missed with the kids. They went straight into looking at angles and sides and it came out that they didn't know themselves why this worked. So he was able to help them understand that and see the need of explaining that to kids before launching into deeper content with them.

3. How does this model and participation compare to the level of participation in lesson study (district-wide)?

RTP^3 Partner School District A Designee: The project followed Lesson Study Step by Step by Catherine Lewis, and (School District A) does as well so we did have the same components but the addition of the knowledgeable other was something we had never been able to try before. In some cases coaches would sit in and say they were the knowledgeable other, but getting someone with this broad scope of knowledge and being able to take something from

foundations to what someone having knowledge all the way to their doctorate in math could do had never happened before. Not just a coach but someone with a much deeper knowledge.

We also explored the idea of putting together people from different schools and not just having a science team together. Once you get into secondary, life science is not the same as earth science just because they are both sciences. Even though it was about the strategies it could be difficult for them to stretch that far away from the content they were used to. So these cross district teams were useful. We normally do half days but with travel time coming from different schools we were able to do it in one day. We had 36 teachers just this year not including the first year so it did help us expand as a district and reach schools with lesson study where we hadn't before, schools that had been resistant or never shown an interest, and also helped build the capacity in their facilitators. If they had been to training and never done it, we would co-facilitate with people from the school and give them the opportunity to practice.

4. How did you track participation in and results of lesson study experience for mentors and resident teachers?

RTP^3 Partner School District A Designee: We have a very sophisticated tracking system, we track participation a couple different ways. One way is looking at attendance--we keep evidence of every cycle of lesson study we do. We have a template we use; first thing is the date, who was there, who participated on team and who facilitated. We capture all the work they do--deconstructing the standard, the research article they read, the data analysis piece, the questions and conversations that came up during the reflection, what teachers learned. We also have a living breathing document in which we keep information on the school that participated, cycle number, benchmark they chose to explore, how many cycles each team does, how many cycles a school does, how many cycles the facilitators support.

In addition with RTP^3 (we don't do this with all of the others,) we had a three question format after the process that asked them where did they stretch their thinking, what is something you want to continue about, and how did this experience relate to your deliberate practice. So we got some feedback from teachers and mentors; a lot of the feedback from mentors--they would say things like "Now I know what she's talking about when she talks about her team," and "Now I can think of some ways to help her integrate better with this team," so it was great for the mentors to see the teacher with their team if they had fragile relationships, it really helped them have perspective.

5. To what extent did your district modify lesson study implementation in general as a result of participation in RTP^3?

RTP^3 Partner School District A Designee: We became open to that idea of cross content teams and doing lesson study in a day as opposed to the half-day model we used previously. Both are fine but if we have teams with teachers from different schools we need to do something that will be less intrusive on their time. Also the knowledgeable other and having those contacts and seeing if there are other ways we can incorporate the knowledgeable other into our teams.

Interview with RTP^3 Partner School District B Designee, Conducted at 8:00 am on Friday, October 3rd, 2014

1. Please tell me about your school district's interest in participating in RTP^3.

RTP^3 Partner School District B Designee: Well, our interest of course began when we were approached by UCF to see if we wanted to be a partner district. I came in kind of after the fact that we were already a partner, but I was there for the first hiring, for the first cohort, and it was a little difficult to get schools to take the risk to hire these people that had no experience, but they had STEM degrees. So that first year we were supposed to hire fifteen and we only hired ten, but that was because there were so few in the pool. UCF didn't get the numbers that they anticipated. The district's interest was that we wanted to bring STEM education into our district, and the best way to do that is to have STEM degreed personnel teaching.

2. Please describe your school district's RTP^3 lesson study model, addressing how lesson study was conducted and who made up the lesson study research teams.

RTP^3 Partner School District B Designee: We used the RTP^3 model that was created, which is very similar to our district one. In fact we had personnel from our district help to create the RTP^3 model. The research team consisted of, the first year was one way, and the second year was a different way because we had to make some changes. So the first year because we mandated that all of our RTP^3 people participate in at least one lesson study, a lot of times the schools were not wanting to participate. So we had to create teams that were not really as beneficial as they could have been. They were cross-district, they were cross-curriculum, they were just to get the people through the program, the process, one time. That was not beneficial at all. I felt that that was a waste of time, and I mentioned that at our meetings, our board meetings that to me that was a waste of time and a waste of energy, nothing was gained out of

that. So we made changes for the next year. And the next year what I did was I put like content-area, and even though it may have been across the district different teachers, I had all the chemistry teachers together, all of the physics teachers together, all of the middle school science teachers together, all of the middle school math, all of the high school math, and that was more successful. In the second year we did two cycles instead of one.

3. How does this model and participation compare to the level of participation in lesson study (district-wide)?

RTP^3 Partner School District B Designee: It was supposed to be a district-wide initiative. Many schools did not participate at all. It's a great idea and our district really wants to do it, however with the high-stakes testing we have to go through and the time it takes (it's difficult). 8th graders have 127 days of testing out of 180 days in the school year.

4. How did you track participation in and results of lesson study experience for mentors and resident teachers?

RTP^3 Partner School District B Designee: I didn't really track the results after the fact, after the initial lesson studies. We did two cycles, which was twice that I was able to receive data from them. They would show me their observations in their walkthroughs and things and indicate they had changed things and gotten an improved rating due to lesson study. All 16 of our teachers last year received an effective or highly effective on their evaluation.

5. To what extent did your district modify lesson study implementation in general as a result of participation in RTP^3?

RTP^3 Partner School District B Designee: They did not modify it at all. I don't know if they are even still doing it anywhere this year.

Interview with RTP^3 Partner School District E Designee, Conducted at 2:25 pm on Tuesday, August 26th, 2014

1. Please tell me about your school district's interest in participating in RTP^3.

RTP^3 Partner School District E Designee: I think that originally it was mostly about having some STEM teachers and wanting to be more involved in having first year teachers. I wasn't involved in the early planning, I came on after they had already applied for the grant but I think that was the initial idea, to have more participation in getting young STEM teachers brought on to (School District E).

2. Please describe your school district's RTP^3 lesson study model, addressing how lesson study was conducted and who made up the lesson study research teams.

RTP^3 Partner School District E Designee: We had never done lesson study before. Because we are virtual it had to be done differently, so we started the first year by putting together four different teams according to the subjects the RTP^3 teachers were teaching and involving the mentors. We had a face to face meeting first to plan the lesson. We did one group that was virtual. So we had four groups that were face to face lesson planning and one that was virtual. By doing the virtual we had one biology (team) that was completely virtual and one (biology team) that was done face to face so we had some comparison there. Everybody delivered the lesson virtually because that's how our students work. The remainder of the meetings including the data analysis was done virtually. That allowed us to see how it could work virtually, so the second year we had five groups and all were completely virtual. We did it through blackboard collaborate; we had numerous shorter meetings to plan. About six hours of planning time was done to plan the lesson virtually.

3. How does this model and participation compare to the level of participation in lesson study (district-wide)?

RTP^3 Partner School District E Designee: None had been done prior to this. After the first year they did choose two groups of teachers outside of RTP^3 to do lesson study and they each did one cycle. We are now going almost districtwide with virtual lesson study using the same model from RTP^3.

4. How did you track participation in and results of lesson study experience for mentors and resident teachers?

RTP^3 Partner School District E Designee: Not sure how to answer that, we expected them to participate and they did. We took attendance and everyone participated. If anyone couldn't make it, we rescheduled. With the results, we did a survey of each lesson study group right afterwards. Sent all of them a series of questions to discuss what they learned, what they thought went well, what could be different, and they all completed that. We shared that of course with RTP^3.

5. To what extent did your district modify lesson study implementation in general as a result of participation in RTP^3?

RTP^3 Partner School District E Designee: We have expanded lesson study districtwide. RTP^3 basically gave us the knowledge that we needed to be able to implement it. We are now developing an online intro to lesson study course and a virtual facilitator course that will be able to be used in the future.

APPENDIX D:
TABLE OF ALL QUOTES THAT RELATE TO LESSON STUDY FROM SCHOOL DISTRICT A RESIDENT TEACHER LESSON STUDY REFLECTIONS

Table 12

School District A Resident Teacher Lesson Study Reflections

Alphanumeric Code	All Quotes that Relate to Lesson Study
Female Biology A.1.1	Therefore it was a great experience to have the opportunity to discuss lesson ideas with other teachers in the same discipline.
	We were able to dig deeper and start predicting what we would see and hear from students and the teachers as the lesson unfolded.
	This was an ah-ha moment for me because I never really sit down and think about what I should see the students doing and hear them saying as a lesson continues.
	I loved it.
	I think we should have to complete a lesson study at least twice a year for professional development.
	The research that goes into the observation of the students and what parts of the lesson worked and did not work and for what reasons is a whole other level of reflection.
	I got a chance to discuss some of what other AP biology teachers are facing as far as the labs and testing and just ways to ensure the curriculum stayed on a steady pace during the year.
	I believe my tools of instruction strategies in AP Biology were heightened through this experience.
Female Biology A.1.2	When I participated in Lesson Study on April 2, 2013, I was delighted to find the scientific method applied towards the development of pedagogy.
	When we regrouped after lesson study, we did a gallery walk of our recordings and I found it very interesting to see how the lesson could be pieced together using quotes and actions from students.
	It was interesting to see what my colleagues noticed, and what I may have missed.
	When we reflected on the lesson, we found many areas that could be improved upon to support the lesson goal.
	We found that predetermined groups might be more effective for collaborative purposes, we developed a sense of how much time should be allocated for the lesson, and we revised and revamped the lesson in order to make it more beneficial for students.
	Overall, I really enjoyed collaborating with my colleagues and mentors during lesson study.
	I have recognized the cumulative benefit of collaboration, and just how much insight can be gleaned from additional input.
	I also recognized that I don't regularly reflect on my lessons, and if they satisfied the learning goals.
	What I hope to take from this experience is more opportunities to collaborate with my mentors, and an improved habit of reflecting on the results of my lessons.

Alphanumeric Code	All Quotes that Relate to Lesson Study
Female Biology A.1.3	There are some aspects of the lesson that were planned carefully and executed according to plan and there were a few things that caught my attention as I was observing the lesson that really made me think about the planning process.
	Had we planned for students "getting it" we could have gotten more data to analyze at the end of the lesson.
	This reminds me of Marzano's high expectations for all students.
	It made me realize that we as teachers often only plan for students not "getting it".
	Another item that grabbed my attention was the lack of planning for specific logistics of the lesson.
	Even though there were a couple of flaws in the planning process, I really feel like this lesson study has been the most helpful to my development as a teacher.
	I mean the whole point of lesson study is to recognize flaws in planning so that we may reflect and adjust our teaching practices.
	And the best part of all was getting to collaborate with not only teachers from my school, but my mentor who teaches at another school and the lesson study facilitators.
Female Biology A.1.4	I enjoyed participating in the creation of this lesson.
	It gave me a new perspective on how students react to given wait times and collaborate in groups.
	In this lesson we attempted to plan with a focus on wait times following questioning.
	The lesson also supported the notion that in a science classroom students learn from one another and work together to attain a goal.
	Planning a lesson together was fun, and I thought that being able to bounce ideas about activities and questions for the students was helpful in planning a successful and cohesive lesson.
	After participating in a lesson study cycle, I am excited to continue using lesson study for professional development.
	I would like to build on this lesson study and complete more science centered studies.
	Lesson study is an innovative way for new and experienced teachers to reevaluate their methods and to develop new ones.
Female Biology A.1.5	I found this lesson study experience very interesting.
	I enjoyed listening to my colleagues' ideas and suggestions on how to teach this lesson.
	It was refreshing to have not only one new point of view to consider, but many, since everyone in the lesson study participated in putting forth our ideas.
	It was interesting to be able to sit and listen to the students as they interacted with their knowledge and the activity.
	Overall I really enjoyed this lesson study and hope to be able to participate in more.
	My only concern is the amount of time required for it.

Alphanumeric Code	All Quotes that Relate to Lesson Study
	My department (as I'm told the rest of the county as of now) is behind in the curriculum and taking time out of the classroom to participate in things like this place us further behind.
	Hopefully we can come up with better ways to schedule events like this and have more support in our classrooms for our absences.
Male Biology A.1.1	At my school I am the only science teacher, so this was a wonderful opportunity for me to collaborate with other science teachers, share notes, and see how they utilize their resources and present the information to the students.
	One of the most surprising aspects of the Lesson Study was how long it took for us to all agree on the wording for the learning goal and the learning scale.
	That this aspect of lesson planning could fill up an hour long meeting, or that there is so much room for analysis within it came as a surprise/revelation to me.
	One of the big things I realized in lesson study is that it is not about the lesson as much as it is the teacher.
	The great benefit of lesson study was not in the collaboration stage, in designing a better lesson with other teachers--I could download off of the internet as many lesson plans as I need, all of which were made via the collaboration of more teachers than I have available at my school--no, it was in watching another teacher give a lesson, and being able to compare at each step along the way what you would have done different, and then being able to observe the outcomes and learn what worked better and what did not.
	I am grateful for the opportunity to see how other teachers use their resources.
	Even though I don't have all the same resources available at my school, there are many things I hadn't thought of that I can easily purchase or bring in to the school.
	The lesson study experience has helped me to improve my lesson planning, but more importantly it helps me to objectively see where I could be better, and how.
Female Middle School Science A.1.1	In the program there are no other Earth Space Science Teachers in (School District A). So I worked with one from (School District B).
	Since we were in such different places we decided to plan separate lessons and then just do similar teaching techniques.
	I feel like this activity told me a lot about where my students were.
	I saw that they had a good idea about the planets and their order in the solar system but they didn't know a lot about the specific properties in the benchmark.
	It gave me a great idea of what I needed to cover and how to cover it.
	I think that I would like to incorporate this activity more often.
	I would say a downfall of this activity was that I only saw what the table knew not each individual student.

Alphanumeric Code	All Quotes that Relate to Lesson Study
Male Physics A.1.1	My peers and I were excited for the opportunity and during the pre-meeting we decided to cover the topic of plants.
	During the process of lesson study one of the most interesting aspects of lesson planning wasn't how to choose how to present the topic or how the students should show what they learned, those came to us easily.
	What seemed like simple questions such as how do you handle misconceptions that students have early on turned into a large debate over whether you should let students continue to have that misconception and learn that it is false as the lesson carries on or if it is more beneficial to students to see that it is a misconception immediately.
	Having the opportunity to see how more experienced teachers approach a topic like student understanding was invaluable to see how their thought processes at work.
	As a teacher that began without a background in education the lesson study also served as an exciting opportunity to watch an experienced teacher in their own element of planning, teaching, and critiquing their lesson, something I haven't had much opportunity to see.
	After the lesson study I have made attempts to put more thought into the way in which I'm having my students learn a new topic and I've tried to design more ways for my students to demonstrate their learning throughout a unit.
	I'm very appreciative to have had the opportunity to have completed a lesson study this year.
	It was very helpful for me to see how other teachers prepare and present lessons and because of that I was able to better learn how to do it better myself in the future.
	I really enjoyed the opportunity and would be very open to it again in the future.

APPENDIX E:
TABLE OF ALL QUOTES THAT RELATE TO LESSON STUDY FROM SCHOOL DISTRICT A RESIDENT TEACHER WORK SAMPLE REFLECTIONS

Table 13

School District A Resident Teacher Work Sample Reflections

Alphanumeric Code	All Quotes that Relate to Lesson Study
Male Mathematics A.2.1	No quotes related to lesson study observed
Male Physics A.2.1	Working together in a PLC like this made me very happy, as I was able to have someone to help me come up with new ideas, but also allowed me to have someone who knows the subject matter to bounce my ideas off of.

APPENDIX F:
TABLE OF ALL QUOTES THAT RELATE TO LESSON STUDY FROM SCHOOL DISTRICT B RESIDENT TEACHER LESSON STUDY REFLECTIONS

Table 14

School District B Resident Teacher Lesson Study Reflections

Alphanumeric Code	All Quotes that Relate to Lesson Study
Female Biology B.1.1	As a novice teacher, I appreciated watching veteran teachers demonstrate a lesson. My fellow teachers exposed me to various teaching styles, as well as, excellent articles to borrow for next year!
	I also enjoyed watching the other teachers' classroom management styles.
	The best part of this modified lesson study was the opportunity to watch others teach lessons and use strategies that I have not yet thought of or been exposed to.
	Overall, I enjoyed this modified lesson study.
Female AP/Gifted Biology B.1.1	I was able to collaborate with another (School District B) Biology Honors teacher in the RTP³ program.
	Although the planning stage presented a problem for us, since her school was a week ahead of mine in the curriculum, the compare-and-share afterward was invaluable.
	Although I found it difficult to perform a true lesson study within the provided timeframe, my collaborator and I discussed the effectiveness of each of our strategies.
	I greatly enjoyed being able to collaborate with a teacher outside my school.
	Although I have an extremely cooperative PLC among the biology teachers at my school, it was a welcome change to expand our collective idea bank by working with someone coming from a different school who has a different set of resources from her own planning and from the other teachers in her PLC.
	I think this type of cross-school collaborative compare-and-share was one of the most valuable experiences that the RTP³ program has provided.
	In fact, I hope to one day establish a collective of teachers from various schools who meet to share lessons and effective activities that we can bring back to our own schools.
Male Life Science B.1.1	It was very interesting to watch how the other teacher completed the scripted lesson and how the students responded to the lesson.
	It was challenging to not help the students to complete their understanding of analyzing graphs, as those items were not included in the original lesson plan.
	Overall, I thoroughly enjoyed the lesson study process.
	I feel that the lesson study model promotes educators to collaborate and create lesson plans that are highly effective in impacting student engagement and learning.
	It was rewarding to work with a group of peers who are consistently striving to become better professionals and I was able to learn and see new techniques and strategies that can be utilized in my classroom.

Alphanumeric Code	All Quotes that Relate to Lesson Study
Female Mathematics B.1.1	Participating in the lesson study was very insightful for me.
	I learned so much about the entire process and how much planning goes into it.
	During the lesson study event the participants were respectful and open to listen to everyone's opinions.
	Working with fellow colleagues exposed me to different point of views and different approaches to implementing a lesson.
	In some instances it was difficult for everyone to reach a final consensus.
	While executing the lesson I was surprised at how many anticipated student responses we left out.
	We began the lesson study by first setting norms. I really liked this part because it set the guidelines that we would follow.
	The last guideline made me feel open to expressing my true opinions because I wouldn't have to worry about anyone disrespecting me.
	At first it was intimidating for me to voice my opinions but as time progressed it became easier.
	Listening to the student responses provided a lot of insight in terms of improving the lesson.
	As I observed student questions such as "where does the tape go?" it became evident that developing an effective lesson is a collaborative effort that requires input from different viewpoints.
	This made me realize that it is a privilege to work with colleagues because they can bring different ideas and ways of thinking to the table.
	It was good to hear the other member's responses because they introduced phrases that I had overlooked or never thought of. Once again this made me realize the importance of collaborating.
	In conclusion, I learned so much from this lesson study.
	After participating in this lesson study I can effectively visualize what lesson study is and how it can be used to impact student learning.
Female Physics B.1.1	My experience participating in the lesson study for high school science in (School District B) was very eye opening to the process of working together with colleagues to design an engaging activity for high school.
	After actually participating in the lesson study in my county, I fully understand the process and why it is beneficial for both teachers and students.
	My lesson study team consisted of four high school science teachers within the county. Two of us taught at the same school and taught the same subjects while the other two taught different subjects at different schools.
	When we first got together to plan our lesson, I was skeptical of the logistics of creating it.
	Unfortunately the week we planned to actually teach the lesson, I was very sick so I could not be a part of the teaching process.

Alphanumeric Code	All Quotes that Relate to Lesson Study
	The benefit to doing a lesson study is that all the teachers get to collect data on how well the lesson goes and how well the students understand the material.
	Overall, my experience in the lesson study was positive and I would definitely be open to doing this again.
	I think it would be more effective to do lesson study with teachers of the same subject but this opportunity gave me a glimpse into how the process works.
	If we are required to do lesson studies in the future at my school, I will feel more confident about the process and more prepared as a result of this activity within the RTP³ program.
Male Physics B.1.1	During our lesson plan we faced the challenge of planning a universal lesson for high school science teachers. Our group ranged from standard to honors to AP level in subjects ranging from biology to physics to chemistry.
	If we had the chance to do a second round of lesson study I think we would give less wait time and keep the students more engaged.
Female Mathematics B.2.1	It was helpful to break the lesson plan into different components, such as preparation and research, a written plan, a presentation, some form of assessment. It was also crucial to always keep the focus of the lesson in mind as we were planning the lesson to ensure that all of the lesson learning goals and objectives were met and that the areas where students were having difficulties with were targeted.
	This lesson study was a good reminder that the focus of a lesson is on student learning and the needs of the students.
	Also, planning the lesson collaboratively helped give me ideas for my own lessons in the future and different methods and strategies for creating a lesson plan and types of activities I could include in the lesson to engage the students.
	It was nice to see it from the perspectives of other teachers, especially as a new teacher, and see their ways and ideas of approaching teaching a lesson.
	However, I realized that the results from teaching the lesson will help modify future lesson planning and that there are always ways to improve upon a lesson, no matter how many times you teach it.
	Thus, I think, even though lesson studies are time consuming, they are very useful and beneficial, and I will continue to think and reflect upon my lessons in the future as I did within this lesson study.
Female Mathematics B.2.2	Overall, it was very helpful to see my own students react to the lesson. I was able to observe so much more than I normally do while I'm teaching.
	I was able to gather information on their learning, and on their engagement.
	After the lesson study, I decided to be more proactive about my classroom management.
	I realized that engagement is a major component of every lesson, so I will try to improve it through carefully planned lessons and classroom management.

Alphanumeric Code	All Quotes that Relate to Lesson Study
Female Mathematics B.2.3	The first lesson study was during the first semester, and consisted of teachers of different subject areas, such as Chemistry, Biology, and Math. Even within the math teachers, we all taught different subjects of math.
	This proved to be difficult when creating our lesson.
	We therefore opted for a lesson dealing with proportions, which is important for all science and math subjects.
	For the first lesson study, we did not have two full days but instead had a three hour meeting after school to create it and a full day the next week to teach it.
	We therefore did not have enough time to create the lesson, and had to finish the final details through email.
	Following the first lesson study, I had a better idea of how a lesson study went and saw the potential use of them on a regular basis.
	For the second lesson study, we were given two full days back-to-back.
	We were also all Math teachers, and consisted of both first year teachers and veteran teachers.
	Since we all taught different subjects of math, we decided to focus on Algebra I topic.
	The process of creating the lesson was not nearly as stressful as the first lesson study, and we were done at the completion of the first day.
	Although I had more stress in the second lesson study, I got more out of it than the first one.
	It was much more organized and I feel that I truly experienced what a lesson study is meant to do.
	I think more teachers should participate in lesson studies; however I don't know the best process to incorporate them.

APPENDIX G:
TABLE OF ALL QUOTES THAT RELATE TO LESSON STUDY FROM SCHOOL DISTRICT B RESIDENT TEACHER TEACHER WORK SAMPLE REFLECTIONS

Table 15

School District B Resident Teacher Teacher Work Sample Reflections

Alphanumeric Code	All Quotes that Relate to Lesson Study
Female Chemistry B.2.1	I have collaborated immensely with my other cohorts and have gained invaluable information from them whether it is based on the procedures in the classroom, the teaching strategies they use, or if they explained a similar concept in my subject area one way versus another. I gladly accept feedback from other teachers as well and openly seek for mentorship in areas that I am lacking in.
Male Chemistry B.2.1	While technology is becoming more and more pervasive in the 21st century classroom, there are still old school techniques that are unbeatable, like collaboration with other teachers. The unit lesson plan was designed with tremendous insight from other teachers within the department. With the dry ice explosion demonstration, a demonstration relating the effects of increasing pressure on a closed, rigid container, the AP Chemistry teacher was consulted for pointers and advice on the lesson. In the future, further insight could be utilized to help better relate to students, such as finding real-world experiences, laboratories, and demonstrations. While I have tremendous ability to relate classroom content to real-world experiences, I am limited knowing how to bring those real-world experiences in the classroom. The department has, on average, 15 years or more experience, and I can greatly benefit from their advice for how to bridge content with memorable demonstrations and lab activities.
Male Chemistry B.2.2	No quotes related to lesson study observed.
Female Mathematics B.2.4	I have talked with the other members of my professional learning committee about what data would could pull from giving a pre and post assessment; and they agree to make pre assessments fit into our instructional plans during next year.
Female Middle School Mathematics B.2.1	No quotes related to lesson study observed.
Female Middle School Science B.2.1	No quotes related to lesson study observed.
Female Middle School Science B.2.2	No quotes related to lesson study observed.
Male Physics B.2.1	No quotes related to lesson study observed.
Male Physics B.2.2	No quotes related to lesson study observed.

APPENDIX H:
TABLE OF ALL QUOTES THAT RELATE TO LESSON STUDY FROM SCHOOL DISTRICT E RESIDENT TEACHER LESSON STUDY REFLECTIONS

Table 16

School District E Resident Teacher Lesson Study Reflections

Alphanumeric Code	All Quotes that Relate to Lesson Study
Female Algebra E.1.1	We followed the guidelines from Lesson Study Step by Step: How Teacher Learning Communities Improve Instruction (Lewis 2011).
	It was very interesting to watch the lesson develop from an idealistic lesson to the actual lesson taught.
	If I were to do the lesson study process again I would want to break the planning up into at least two days and complete everything as a group either online or face-to-face.
	It appears as though a lesson taught online takes more time than the same lesson taught in the regular classroom.
	After participating in this lesson study I would like to see the lesson be more adventurous by trying new techniques and I would like to spend more time as a team planning the lesson and creating the slides.
	I look forward to the next lesson study to improve not only my teaching practices, but to explore and improve online teaching practices in general.
Male Biology E.1.1	I really enjoyed participating in the lesson study this semester.
	It was very unique as the whole lesson study was done virtually.
	The goal of the lesson study was to evaluate the growth of our students based on the writing activity that they needed to complete.
	Both students at the end of the lesson made a lot of growth compared to when the lesson began based on the students opening statement.
	This showed great evidence that our lesson study was a success.
	All in all the lesson study was a success and it was extremely helpful collaborating with all the teachers.
	Everyone had something to contribute and it was a stress free working atmosphere.
Male Biology E.1.2	We may have had four different planning sessions which spanned from March to April.
	A lot of time teachers were not able to attend sessions because vacations, taking children to school and many other schedule conflicts.
	I believe this may have proved why it is so much more beneficial to have a face to face lesson study instead of virtually.
	The lesson started on time however only one student was present.
	Honestly I would definitely teach this lesson again and work with the same group for any other lesson studies.
	We set rules for our planning sessions and we all showed respect for one another.
	Lesson studies are very important and I think these sessions should happen all throughout the year.

Alphanumeric Code	All Quotes that Relate to Lesson Study
Female Biology E.1.1	The lesson study exercise conducted by the RTP³ interns at Florida Virtual School was done a little bit differently than lesson study is traditionally conducted.
	All of the lessons were delivered virtually.
	This was definitely a learning experience for all parties involved, and I hope that our efforts will be the foundation for continuing the lesson study process at (School District E).
	I think we could have been more efficient if we had discussed some organized way for us to communicate.
	Everyone agreed that the lesson study was too rushed, and we left our discussion there.
	Since we were not going to teach the lesson again after the debriefing, we had nothing more to say.
	I disagreed with this, as not teaching the lesson again after discussing improvements defeated the entire purpose of doing the lesson study.
	To me, it just seemed like everyone wanted to get it over with instead of taking the chance to do it right.
	I hope they find a way to more effectively conduct lesson studies in the future that will be more beneficial to them.
Algebra 2 Team E.2.1	There was great student participation.
	The data collections process, if defined precisely can lead to gathering of information to aid in the improvement of the lesson delivery.
	The shift in the lesson increased student engagement.
	I thought this was most informative! We made basic changes (e.g. changing the problem example, changing the graphic, having a "teaser" problem at the beginning, etc.) and student engagement greatly improved as the result of the newly-improved lesson.
	By actively engaging students and including them in the learning process helps guarantee their success with the material.
	Asking for answers in different ways (a green check, type in the chat area, A, B, C, happy face, etc.) allows for more interaction during the session.
	The collaboration went smoothly.
	Everyone followed the group norms and understood their roles.
	There was equal participation throughout the cycle.
	Teachers were, for the most part, willing to work extra in order to make the changes that they felt were needed to make the lesson better.
	Some members of the group made it a little harder on everyone else by not keeping the dates agreed on at the beginning of the cycle.
	I gained new insight into the value of posing thought-provoking questions to students.
	If they are responding and answering the questions, then they really do learn.

Alphanumeric Code	All Quotes that Relate to Lesson Study
	I loved how Lesson Study is more about the process of collaboration--which leads to greater, documentable, student outcomes--versus just creating something yourself and using it without reflection.
	This was the first chance I have had at (School District E) to really pick apart a lesson and that was very beneficial.
	Lesson Study helped us focus anew on student achievement in a way that provided real data on effective, increased learning.
Biology Team E.2.1	The team collaborated very well. Everyone was respectful and a team player. There was a very equal share in workload and response.
	The students seemed to interact more when there was less reading and more interaction.
	I learned how to make the links live, how to do a pre- and post- test, how to improve upon this lesson, confirmed what I thought was working well and brought to my attention that the reading passages need some work (shortened with pictures).
	Instructional design decisions, both visual and content-based, will directly impact how well students retain information.
	Furthermore, it seems to be a beneficial practice to have a skilled observer present during a session to collect data on a lesson, given that some student behavior can be overlooked easily when a teacher is immersed in instruction.
	Lessons need to be revised and revised again to be sure they flow well.
Chemistry Team E.2.1	We were very successful in working as a team to create and present a live lesson that allowed for the collection of student data.
	We did successfully gather data, but it was hard to fully determine meaning from the data that was collected.
	Some of the data may have been tainted by the fact that the presenter did not have prior experience with the lesson and that the lesson went almost double the planned amount of time.
	Allowing the students to figure out how to solve problems and use equations on their own was very effective in producing mastery.
	The time commitment was perhaps greater than expected, but it was understood that with the tight timeframe some people had to leave meetings early.
	There are many different types of people on the team (data driven, creative, funny, serious, etc.), which makes it well-rounded.
Geometry Team E.2.1	Time was one of the biggest factors in our lesson. As such, it would be necessary in the future to remove certain aspects of the lesson.
	Due to the limited number of students, it would make sense to more aggressively campaign for attendance.
	The only thing that I was disappointed with was how we divided up the actual creation of the content.
	I do wish that one of the interns did the teaching so they could gain more experience.

Alphanumeric Code	All Quotes that Relate to Lesson Study
	The individuals who worked on this lesson study did an outstanding job working together as a team.
	Each member contributed throughout the entire cycle and provided valuable insights on the development of the lesson.
	They also respected each other's time and schedule as well as any differences of opinions.
	I was able to get a glimpse of the thought process that more experienced teachers use to plan lessons. Being a relatively new teacher, this is one area that I struggle in greatly.
	I gained insight on the data that can be collected from a session and the validity of a session.
	Moreover, I learned about other instructor techniques, finding new ways of teaching the same concepts.
	It became apparent to me that students learn much more efficiently when they are given the opportunity to interact with the content in many different ways.
	Student learning takes place based on student engagement and I feel that this lesson actively engaged the students.
Physics Team E.2.1	The team I am on is amazing. The depth of experience that Norma and Michelle have is frankly astounding. It was certainly a great help to work with them through this experience.
	We worked together with the common goal of making sure that students learn momentum and to present the best possible lesson.
	It was eye opening to go through the process of the lesson study.
	A Live Lesson that we have had in place for years and we thought were fine have definitely been improved.
	I look forward to altering the other Live Lessons with what we learned in this cycle.

APPENDIX I:
RTP^3 LESSON STUDY MODEL

The following RTP^3 lesson study model comes from a personal communication sent by R. Taylor, RTP^3 Principal Investigator, and S. Powell, RTP^3 Project Director, to K. Pippen on March 21, 2014. The model is included in its entirety.

The final RTP^3 Lesson Study Model was agreed upon by a representative from each of the partner school districts and the UCF project PI and Project Director. The process used to come to consensus was to review past meeting notes and each partner school district's model. Changes to the model agreed to in July 2013 are included as well as revisions recommended due to findings of feasibility and impact on quality of lesson study outcomes.

The collaboration among school district partners and the university has resulted in lesson study being included in future college clinical experiences. When a school has lesson study available, university interns will participate as part of their internship. To accomplish this, intern coordinators are encouraged to participate in lesson study professional learning and on lesson study research teams, as are university faculty.

RTP^3 Lesson Study Model Components

The Lesson Study Work Group divided the components in two groups: essential and preferred. This division is based on the experience in implementation across diverse contexts and with experienced and inexperienced teachers.

It should be noted that while the work group believes that when an expert is present as the knowledgeable other, the learning outcomes for teachers are greater. However, a true expert in content and pedagogy is not always available. In many instances a school or school district-based instructional coach or teacher leader has been in that role, but often the lack of deep expertise has detracted from the participants' learning outcomes. The recommendation is that it

is best to have a true disciplinary expert, most likely from the local university, to be present at least during the lesson teaching and the debriefing experience.

RTP^3 Lesson Study Research Team Model: **Essential** Components

- Attend professional learning prior to participation.
- Include creation of professional learning community norms of collaboration.
- Align with Next Generation Science Standards (NGSS), Common Core State Standards (CCSS), and Florida Standards.
- Research common misconceptions related to the target standard.
- Develop standards-based lessons (NGSS, CCSS, or Florida Standards).
- Be collaborative.
- Collect evidence/data and analyze evidence/data.
- Focus on learning and learners.
- Include reflection.
- Participate in at least one lesson study cycle during academic year in schools.

Participate together as mentee and mentor. RTP^3 Lesson Study Research Team Model: **Preferred** Components

- Include knowledgeable others (school district or university content expert).
- Teach the same course (participants).
- Start early in the school year.
- Participate in at least two or more lesson study cycles during academic year.

RTP^3 Lesson Study Model Steps

The RTP^3 Lesson Study Model includes specific steps. These steps are the process that takes place within the lesson study research team after they have participated in professional learning. The order of the steps may vary as well as the specifics noted within the steps depending upon context. Examples include a live lesson in the virtual environment or recording the lesson for those not in attendance to debrief.

1. Agree on norms of collaboration.
2. Review lesson study process and correct misconceptions of the mental model.
3. Identify the standard to be address in the lesson.
4. Analyze the standard and clarify the student success criteria and rigor expected.
5. Research student misconceptions regarding the standard.
6. Create the learning goal, learning scale, and other items that are school/school district expectations.
7. Plan the lesson to align with #6.
8. Create manipulatives or select instructional resources.
9. Decide the time/period during which the lesson will be taught.
10. Randomly select the one to teach.
11. Clarify roles of other research team members and the tools they are to use.
12. Teach the lesson and gather data/evidence.
13. Debrief the lesson and analyze data/evidence, which may include prompts.
    - What have you learned....?
    - Think of lesson enhancements that may be helpful?

- What applications would be useful in increasing learning of other standards?

14. Enhance the lesson based on conclusions.
15. Repeat #9-14 as time permits.

RTP^3 Lesson Study Model Resources

These resources as well as other RTP^3 common texts are used in the professional learning for lesson study and for facilitators. Further, sections are used as review materials as each lesson study cycle begins and the lesson study research team's understanding develops. Although the Lewis and Hurd (2011) resource has been helpful its target is elementary teachers and it is not aligned with high accountability standards-based instruction. Therefore, there is a need for a resource that specifically targets middle and high school teachers.

Brunn, P. (2010). *The lesson planning handbook: Education strategies that inspire student thinking.* New York, NY: Scholastic. ISBN: 978-0-545-08745-2

Lewis, C. & Hurd, J. (2011). *Lesson study step by step*. Portsmouth, NH: Heinemann. ISBN: 978-0-325-00964-3

Florida Educator Accomplished Practices

School District's Performance Evaluation System aligned resources

Standards-based resources

RTP^3 Lesson Study Model Professional Learning

First and foremost the professional learning must target the discipline and grade range taught by the participants as noted in the resource section. Feedback from participants in the initial professional learning was clear that they preferred to have the mental model of lesson

study early in the professional learning followed by going more deeply into each step of the process.

The delivery of the professional learning for this project was face to face. However, there is a need to develop an online professional learning opportunity to expand beyond the local area and to serve the virtual teachers across the state.

The mental model should include modeling and reflection on the essential and preferred components of the lesson study model, including how to quickly ascertain misconceptions related to standards. Secondary teachers may not have awareness of misconceptions that grades 6-12 learners have related to specific standards because of fluency with their disciplines.

Facilitators must be experienced in the lesson study process. Additionally, they need targeted professional learning to practice facilitation with skill and confidence. Facilitation does not include directing others, but guiding and providing deep reflective thinking and analysis.

RTP^3 Lesson Study Professional Learning Parameters

- Model Lesson Study Research Team process.
- Model Florida Educator Accomplished Practices (adopted 2010).
- Connect to resident teachers' performance assessment.
- Can be implemented in various contexts, including virtual.
- Model middle and high school contexts with discipline specific teachers.

RTP^3 Lesson Study Facilitator Professional Learning Parameters

- Observe lesson study research team planning.
- Observe lesson study and research team debrief.
- Participate in Lesson Study Professional Learning.

- Participate in Lesson Study Facilitator Professional Learning.
- Participate in more than one professional learning event and facilitate side by side with another facilitator to develop skill and confidence as a facilitator.

Summary of Lesson Study Artifacts

During each of the meetings, the Advisory Board discussed the current status of the school district partners' status with lesson study research teams. In addition, during the monthly Florida Department of Education calls, the school district partners shared the status of lesson study. The school district partners were asked to submit their RTP^3 lesson study model which accompanies this deliverable. The school district partner representative(s) stayed after the Advisory Board meeting for a Lesson Study Work Group session to finalize the final RTP^3 Lesson Study Model based on their findings of what worked well and what did not.

APPENDIX J:
IRB APPROVAL LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Daniel Thompson**

Date: **July 09, 2014**

Dear Researcher:

On 7/9/2014, the IRB approved the following activity as human participant research that is exempt from regulation:

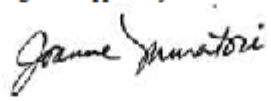
Type of Review:	Exempt Determination
Project Title:	AN ANALYSIS OF THE PERCEIVED IMPACT OF LESSON STUDY ON IMPROVING THE EFFECTIVENESS OF RESIDENT TEACHERS ENROLLED IN THE RESIDENT TEACHER PROFESSIONAL PREPARATION PROGRAM (RTP^2)
Investigator:	Daniel Thompson
IRB Number:	SBE-14-10414
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 07/09/2014 03:14:15 PM EDT



IRB Coordinator

REFERENCES

Artzt, A. F., & Curcio, F. R. (2008). Recruiting and retaining secondary mathematics teachers: Lessons learned from an innovative four year undergraduate program. *Journal of Mathematics Teacher Education, 11*, 243-251.

Beare, P., Torgerson, C., Marshall, J., Tracz, S., & Chiero, R. (2012). Examination of alternative programs of teacher preparation on a single campus. *Teacher Education Quarterly, 39* (4), 55-74.

Benken, B. B., & Brown, N. (2008). Moving beyond the barriers: A re-defined, multi-leveled partnership approach to mathematics teacher education. *Issues in Teacher Education, 17* (2), 63-82.

Cohan, A., & Honigsfeld, A. (2007). Incorporating 'lesson study' in teacher preparation. *The Educational Forum, 71* (1), 81-92.

Darling-Hammond, L., & Richardson, N. (2009). Teacher learning: What matters? *Educational Leadership, 66* (5), 46-53.

Daugherty, M. K. (2013). The prospect of an "A" in STEM education. *Journal of STEM Education, 14* (2), 10-15.

Denton, J. & Davis, T. (2007). Challenges of recruiting candidates with strong academic credentials. *School Science and Mathematics, 107* (4), 121-122.

Evans, L. (2010). Professionals or technicians? Teacher preparation programs and occupational understandings. *Teachers and Teaching: Theory and Practice, 16* (2), 183-205.

Florida State Board of Education. (2012). *Strategic plan for the public school system and the Florida college system.* Tallahassee, FL

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.

Gambino, M. (2013, April 14). How to count to 100,000 STEM teachers in 10 years. *Smithsonian.* Retrieved from http://www.smithsonianmag.com/innovation/how-to-count-to-100000-stem-teachers-in-10-years-23095664/?all

Green, G., & Ballard, G. H. (2011). No substitute for experience: Transforming teacher preparation with experiential and adult learning practices. *The Journal of the Southeastern Regional Association of Teacher Educators, 20* (1), 12-20.

Harris, K. L. & Farrell, K. (2007). The science shortfall: An analysis of the shortage of suitably qualified science teachers in Australian schools and the policy implications for universities. *Journal of Higher Education Policy and Management, 29* (2), 159-171.

Hattie, J. (2008). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. New York, NY: Routledge.

Honigsfeld, A., & Cohan, A. (2008). Lesson study and SIOP help teachers instruct ELLs. *Journal of Staff Development, 29* (1), 24-28.

Hutchison, L. F. (2012). Addressing the STEM teacher shortage in American schools: Ways to recruit and retain effective STEM teachers. *Action in Teacher Education, 34,* 541-550.

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

Lewis, C. C., & Hurd, J. (2011). *Lesson study step by step: How teacher learning communities improve instruction*. Portsmouth, NH: Heinemann

Lewis, C., Perry, R., Foster, D., Hurd, J., & Fisher, L. (2011). Lesson study: Beyond coaching. *Educational Leadership 69* (2), 64-68.

Lewis, C. C., Perry, R. R., Friedkin, S., & Roth, J. R. (2012). Improving teaching does improve teachers: Evidence from lesson study. *Journal of Teacher Education, 63* (5), 368-375.

Luft, J., Fletcher, S., & Fortney, B. (2005). Early recruitment of science teachers: Promising or problematic strategy. *Science Educator, 14* (1), 41-48.

Luft, J. A., Wong, S. S., & Semken, S. (2011). Rethinking recruitment: The comprehensive and strategic recruitment of secondary science teachers. *Journal of Science Teacher Education, 22,* 459-474.

Mangrubang, F. G. (2005). Issues and trends in science education: The shortage of qualified science teachers. *American Annals of the Deaf. 150* (1), 42-46.

McMahon, M. T., & Hines, E. (2008). Lesson study with preservice teachers. *The Mathematics Teacher, 102* (3), 186-191.

Moin, L. J., Dorfield, J. K., & Schunn, C. D. (2005). Where can we find future k-12 science and math teachers? A search by academic year, discipline, and academic performance level. *Science Education, 89* (6), 980-1006.

Morey, A. I., Bezuk, N., & Chiero, R. (1997). Preservice teacher preparation in the United States. *Peabody Journal of Education, 72* (1), 4-24.

Moye, J. J. (2009). Technology education teacher supply and demand—a critical situation. *The Technology Teacher, 69* (2), 30-36.

Newton, X. A., Jang, H., Nunes, N., & Stone, E. (2010). Recruiting, preparing, and retaining high quality secondary mathematics and science teachers for urban schools: The Cal teach experimental program. *Issues in Teacher Education, 19* (1), 21-40.

Office of Science and Technology Policy. (2013). *Obama administration announces new steps to meet president's goal of preparing 100,000 STEM teachers.* Washington, DC

Oppong, Z., de Araujo, Z. U., Lowe, L., Marshall, A. M., & Singletary, L. (2009). Georgia's compensation model: A step in the right direction. *The Mathematics Educator*, *19* (1), 3-7.

Parry, K. W. (2004). Constant comparison. In M. S. Lewis-Beck, A. Bryman, & T. F. Liao (Eds.), *The SAGE encyclopedia of social science research methods* (pp. 181-182). Thousand Oaks, CA: Sage Publications, Inc.

Peterson, P. E., Woessman, L., Hanushek, E. & Lastra-Anadon, C. X. (2011). Are U.S. students ready to compete? *Education Next, 11* (4), 50-59.

Robinson, N. & Leikin, R. (2012). One teacher, two lessons: The lesson study process. *International Journal of Science and Mathematics Education, 10,* 139-161.

Scott, T. P., Milam, J. L., Stuessy, C. L., Blount, K. P., & Bentz, A. (2006). Math and science scholars (MASS) program: A model program for the recruitment and retention of preservice mathematics and science teachers. *Journal of Science Teacher Education, 17,* 389-411.

Sims, L., & Walsh, D. (2009). Lesson study with preservice teachers: Lessons from lessons. *Teaching and Teacher Education, 25,* 724-733.

Simmons, S. A. (2005). Shortcuts to a meaningful career. *Action in Teacher Education, 27* (1), 36-44.

Steinke, L. J., & Putnam, A. R. (2008). Influencing technology education teachers to accept teaching positions. *Journal of Industrial Teacher Education, 45* (2), 71-90.

Swan, B., Godek, J., Zhou, Y., Coulombe-Quach, X., & Katzenmeyer, C. (2012). *Job Embedded Teacher Preparation Program – Resident Teacher Professional Preparation Program (RTP^3) June 2012 Evaluation Summative Annual Report.* (Rep. No. PEER-RTP32012.1-S1). Orlando, FL: University of Central Florida, Program Evaluation and Educational Research Group (PEER).

Swan, B., DeStefano, C., Clark, M. H., Marcus, K., Subedi, B. Katzenmeyer, C., Charles, C., Knote, E., Karcinski, L. & Lavery, M. (2014). *Job Embedded Teacher Preparation Program – Resident Teacher Professional Preparation Program (RTP^3) Final Summative Evaluation Report.* (Rep. No. PEER-RTP32012.1- S4). Orlando, FL: University of Central Florida, Program Evaluation and Educational Research Group (PEER).

Tai, R. H., Liu, C. Q., & Fan, X. (2007). Factors influencing retention of mathematics and science teachers in secondary schools—A study based on SASS/TFS. *Science Educator, 16* (2), 27-32.

United States Department of Education. (2011). *Our future our teachers: The Obama administration's plan for teacher education reform and improvement.* Washington, DC

University of Central Florida College of Education and Human Performance. (2012). *Resident Teacher Professional Preparation Program.* Retrieved from http://education.ucf.edu/rtp3/index.cfm

Ylonen, A., & Norwich, B. (2012). Using lesson study to develop teaching approaches for secondary school pupils with moderate learning difficulties: Teachers' concepts, attitudes, and pedagogic strategies. *European Journal of Special Needs Education, 27* (3), 301-317.

Yuen, L. H. (2012). The impact of continuing professional development on a novice teacher. *Teacher development: An international journal of teachers' professional development*, *16*(3), 387-398.